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THE RAINFALL OF NEW ENGLAND.

GENERAL STATEMENT.

BY CHARLES F. BROOKS.*

[*Received December 1, 1929.*]

New England's position, where the tracks of storms converge at all seasons, and its proximity to the abundant supply of vapor over the Gulf Stream make this region one of good precipitation well distributed through the year. Its generally subdued topography permits but few marked contrasts in short distances. Differences in the amounts of rainfall resulting from the varying exposures to the winds that bring the rains and snows, are particularly noticeable in the White and Green Mountain regions.

In the cold season, there is moderate, though frequent, precipitation in lows passing a short distance north of New England, and abundant falls of rain and snow that attend storms brushing the coast or coming in from the sea. Thus the January average rainfall map shows precipitation from two inches in the north and northwest to three, four and locally even five inches near the coast. The January maxima have been double these amounts.

The heaviest rainfall occurs in southern Rhode Island where south winds, sweeping in from the open sea, are forced upward both by the hilly country, rising to over 500 ft. a short distance inland, and by the margin of the wintertime layer of cold air over central and northern New England. This wetter area is in contrast with the drier Cape Cod area, where both elevation and accumulated cold air are lacking. The January maximum map emphasizes the general feature of wetter coasts, and shows extended areas where over 10 in. have been measured in January. The March maximum map indicates the occasional extreme predominance of coastal storms in the rainfall distribution, with over 14 in. on the coast of Maine. The rainfall of 4 to 9 or more in. generally over the New England states, except Maine, during the storm of November 3–4, 1927, also demonstrates the exceeding wetness of storms from the ocean and the markedly accentuating effect of highlands when acting in conjunction with the circulation in a low-pressure trough.

The rainfall of spring shows a reduction along the coasts, where storms

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are becoming less frequent, and an increase in the interior, where winter cold is giving way to the moderate temperatures of spring with the consequent greater amounts of vapor in the air available for precipitation. Rainfall in the interior in the spring comes both in general storms and in showers, thus providing an amount of precipitation greater than the winter.

The summer rainfall, while still cyclonic in large measure, is much more convectional in type. That is, when the weak lows of summer are passing, their general conditions favor local showers and thunderstorms, which bring rainfall chiefly to the interior, and especially on the White Mountains. Coastal storms seldom occur. Furthermore, the cool waters along the coast hinder the development of heat thunderstorms. Therefore, the interior has more rainfall than the coast. The average in July, for example, is generally four to over five inches in the interior, and from under four to less than three inches on the coast, Mount Washington being wettest, and Cape Cod, Nantucket and Martha's Vineyard, driest. Some summers are extraordinarily wet, when frequent or lingering low-pressure areas pass over New England. Others may be very dry, but even in the driest summers, like that of 1929, appreciable rain falls throughout New England.

The rainfall of autumn is heavy, like that of winter, along the coast of Maine, though still much like the summer values in the south. The interior is still somewhat wet, as in summer, and decidedly more rainy than in winter. A feature of the autumn rainfall of New England is the occurrence of exceptionally heavy rains which attend storms in part, at least, of tropical origin. Though most of the days are dry, rainstorms of one to five inches or more occur. In addition to those of the more or less tropical origin there are, of course, the lighter rains that attend storms of the northern type, which at this season of the year are more numerous and more intense than in summer.

The heavy storms of winter, the storms and showers of spring, the summer thunderstorms and occasional general storms, and the autumn rains of tropical or mid-latitude origin provide a fairly uniform seasonal distribution for all New England. There is, however, a distinct summer maximum and winter minimum well in the interior and a winter maximum and summer minimum on the coast. The summer maximum is due to the strong development of summer showers in the interior and the winter maximum to the frequency with which storms affect the coasts. In the belt between the coast and interior the rainfall is nearly the same in all months.

The total annual amounts of precipitation are generally between 40 and 45 in. The rainfalls are heavier near the coast and on the highlands of the interior, and lighter on the lowlands some miles from the coast, particularly in the valleys of the interior. Near the coast there is greater rainfall, not only because of the relative frequency of coastal storms, but also because the ocean winds that strike the shore are hindered by the land and, therefore, forced to ascend and become cool over the coastal belt. This forced ascent yields its maximum rainfall some twenty miles inland, except

where coastal hilly regions concentrate the ascent nearer the shore. Thus, while the immediate shore has in general from 40 to 45 in., there are rainfalls from 45 to 50 in. some twenty miles inland. Fifty miles inland comes a belt of lower precipitation, 35 to 40 in., except where highlands serve to continue the ascent of winds from the ocean and, therefore, to keep the rainfall amounts equal to those of the coastal belt of heavier rains. Farther inland still, the convectional summer rains, augmented on hills and mountains by the upslope winds of the daytime, are chiefly responsible for another belt of higher rainfall 40 to 50 or more in., the greatest known being the 82 in. on the top of Mount Washington; and it is not improbable that the actual precipitation there is still greater, for the winter precipitation, mostly snow, is so drifted by wind that it is impossible to find a place where the snow falls undisturbed by the wind on this extremely windy mountain top. The slopes may be swept bare or covered deep with snow.*

In contrast to the exceptional amounts that fall on the mountains, pronounced interior lowlands, like those of the upper Connecticut and upper Androscoggin, must get along with 35 in. or less. The lowest rainfalls occur in northeastern Maine (Houlton, 29.1 in.), some distance inland and with cold waters where the ocean is nearest, and the Lake Champlain lowland (Fitzdale, 30.3 in.), in the rain shadow of both the Green Mountains and the Adirondacks and with the summertime reducing effect of the cool lake. The absolute maxima of rainfall in any year are generally a third again as great as the averages, while the minima are about a third less. The highest maxima of annual rainfall are 72 in. in southwestern Rhode Island and 121 in. on the summit of Mount Washington; the lowest minima are 18 in. about Lake Champlain and 16 in. in northeastern Maine.

The snowfall of New England averages more than 100 in. in northern Vermont, New Hampshire and Maine, and also in the southern Green Mountains, and less than 30 in. in the outer portion of Cape Cod and on Block Island. The highest average, 156 in. a year, at Pittsburgh, New Hampshire, in the extreme north of the state, is largely ascribable to the exposure to ascending snow-flurry winds off the open country of Quebec. The extreme amounts in any season for New England range from less than 10 to about 50 to 70 in. in the extreme southeast and from something over 50 to more than 130 in. in the snowier regions of the north and in the mountains.

A detailed discussion of the snowfall of New England by Charles F. Brooks was published in the *Monthly Weather Review*,† June, 1917. A somewhat briefer treatment was presented in the *Geographical Review*,‡ March, 1917.

The following summary of New England snowfall is quoted from the *Monthly Weather Review*, page 285.

*S. P. Fergusson, *Bulletin of the American Meteorological Society*, February, 1929, Vol. 10, pp. 29–30.
†Vol. 45, pp. 281–285, 30 figs.
‡Vol. 3, pp. 222–240, 20 figs.

Air temperature is probably the first factor in determining snowfall. The latitude and altitude differences in temperature cause the heaviest snowfall so far as controlled by temperature to be in the north and on the highlands. Similarly, the most snow tends to come in the coldest month, except in the north in winters colder than usual. Although January is as cold as February, the snow-bearing winds of February are the colder and so the snowier. The warmth of the coast is less favorable for snowfall than the coldness of the interior.

Without precipitation, however, there can be no snowfall. Precipitation is greatest on highlands near or facing bodies of water and near the paths of cyclone centers. The seasonal variations are small in amount.

Wind direction during precipitation is the third important factor controlling snowfall. Windward slopes of mountains and leeward shores tend to have the most precipitation. Combine the effects of these three factors, and the distribution of snowfall in New England may be explained. The highlands are the snowiest; for they are cold, moist, and windy. Particularly snowy are those slopes which are openly exposed to easterly or northeasterly winds or, as in the north, to the westerly winds from the Great Lakes. The intermontane valleys have less snowfall because of the higher temperature, less precipitation, and less exposure. In the coastal region there is plenty of precipitation, and open exposure, for the most part, so that the snowfall depends chiefly on the temperatures. Thus in early winter the snowfall is less than in late winter; in early winter the snowfall on the immediate coast is less than that inland, allowing for topographic influences; and in late winter the snowfall of the coast is the heavier. As New England is the focus of most of the cyclones which cross the United States or come up the east coast, there are chances for wide variations in their paths. On this account all parts of New England are crossed by numerous cyclones. As the strongest ones, however, pass south of New England or cross its southeastern portion, this section from time to time experiences extraordinary snowstorms, a great characteristic of the climate of New England.

The study of New England rainfall which follows is a result of the cooperation of the Massachusetts Department of Public Health, Mr. X. H. Goodnough, Chief Engineer, the United States Weather Bureau Office at Boston, Mr. G. A. Loveland, Section Director, and Clark University Graduate School of Geography, Dr. W. W. Atwood, Director. The Massachusetts Department of Public Health and the U. S. Weather Bureau supplied practically all the data for the study of the average distribution of rainfall. Mr. J. Henry Weber and Dr. Gragg Richards effected the reductions and wrote the discussions under the general direction of Dr. Charles F. Brooks, of Clark University. Weber compiled, averaged and adjusted most of the data and prepared the maps and detailed discussions for the annual and seasonal rainfalls of New England as a whole and for the monthly rainfall of southern New England; Richards reduced, mapped and discussed northern New England; Goodnough, with the assistance of Mr. George V. White, prepared the new tables of New England rainfall and the discussions of the specially heavy rain storms, particularly that of November 3–4, 1927, while Weber and Brooks discussed the meteorological conditions which produced the excessive rainfall of November, 1927.

Since these several studies were first prepared, Dr. John W. Goldthwait, State Geologist of New Hampshire, initiated in 1928, a novel campaign of rainfall measurements at upwards of eighty stations in his state. While two years are insufficient for many general conclusions the data already gathered bring out many significant facts, emphasizing not only the heavier rainfalls of the mountain regions but also the marked differences between the exposed and sheltered slopes. Details of the New Hampshire observations have been appearing in a mimeographed bulletin and in *New Hampshire Highways*, while a summary of the 1928 season was published in the *Bulletin of the American Meteorological Society** in February, 1929.

*Vol. 10, pp. 31-32.

THE RAINFALL OF NEW ENGLAND.

HISTORICAL STATEMENT.

BY J. HENRY WEBER.*

[*Received December 1, 1939.*]

Our first account of rainfall in eastern Massachusetts dates back to 1623, three years after the landing of the Pilgrims. A dry spell began in the third week in May and lasted until the middle of July, and its severity was well-nigh destructive to the hopes and plans of the infant colony. Little rain fell for six weeks, and the weather all the while was exceedingly hot. The corn began to wither, and the highlands became parched. After this experience, it is probable that what would now be called a severe drought did not occur for several years. The hardest trials of the early English settlers appeared in other shapes. Not until 1630 do we find it noticed that "the summer is a good deal hotter than in old England"; while from the fact that, in 1634, it is recorded that "the summer is hotter than many before," we may infer that no great suffering had occurred from droughts up to that time.

Several of the preceding summers, on the contrary, had been exceedingly wet and cold, like that of 1632, causing "great store of mosquitoes and rattlesnakes," while the worms made extensive ravages on the corn.

The next drought of any severity was in 1639, when little or no rain fell from the 26th of April till the 10th of June. There was a very general alarm. "The corn began to wither, and great fear there was it would all be lost." A fast being appointed on account of the drought, "the very day after there fell a good shower." The other years in which droughts occurred, previous to 1650, were 1644, 1647 and 1648, that of 1647 causing great scarcity of provisions. But during this time, more than one winter was remarkable for its severity. In 1641–1642, "Boston Bay was a bridge of ice as far as the eye could see, and the Indians asserted that such a winter had not been known in forty years." Men, oxen, horses and carts passed over the ice with perfect safety for five weeks together. The winters of 1630, 1632 and 1639, also, are mentioned as very sharp and "terrible cold"; but it is probable that they were so only as contrasted with those of England, or on account of lack of sufficient protection against their rigor. In 1645, the winter was said to be "the earliest and sharpest since we arrived in the country."

In the next ten years no considerable drought occurred, but the severe winter of 1644 is worthy of note. As early as the 16th of December, the cold was of sufficient intensity to freeze over Boston Bay, so "that in a very

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few days it was firm to pass betwixt the town and Long Island, and so continued about a month." The harbor was again frozen over in 1659.

Then came in 1662, early in the season, a very great drought, "insomuch that the grass and corn was so scorched there was little likelihood of any harvest." This continued till the 12th of June. The next dry summer was in 1666, when most of the grain was scorched, and the Indian corn eaten by worms. The spring of 1669 was so dry that "the ground in some places began to chop." This was followed in 1670 by another dry summer.

June 14, 1672, was kept as a day of humiliation in all churches because of the great drought; "and the Lord heard prayer, and in hay time much hay was lost by an over much rain." In the following year (1673), the months of March and April being very cold, many cattle died in all parts of the country for want of hay.

In 1675, there was some complaint of want of rain; and in 1681, "in June, July and August, was a great drought throughout the country, to the great loss in corn and grasses, valued at many thousands pounds." The summer of 1685 was also dry though not enough to do any great injury to the crops. In August, 1686, Increase Mather writes: "A great drought; swamps on fire in many parts of the country; could not be quenched. The fire burnt under ground in some places six feet." This drought began early in summer, and continued through June, and till the 18th of July, after which it appeared again. The drought was called "great and terrible." There were also severe droughts in July, 1692, and in July and part of August, 1693. The cold winter of 1697, resembling that of 1641, preceded a summer marked by "a sore and long-continued drought" in July and August.

Thus we have passed over a period of eighty years of the 17th century. The years remarkable for droughts were 1623, 1639, 1644, 1647, 1662, 1664, 1666, 1670, 1681, 1686, 1692, 1693 and 1697, in all fifteen, though a few other seasons, like 1648, were marked by dry weather. This is a smaller proportion than will be found in subsequent years, and the difference may be explained by the fact that the settlers at first had no means of observing accurately, and it is possible that there were more droughts than the number of which we have record, and that, on account of the small portion of the country under cultivation, comparatively little harm arose from an ordinary drought, especially as the settlers relied very much upon the salt marshes and the wet meadows for hay.

In the year 1714, there was a drought of unusual severity. The distinct recollection of it survived many years after. In 1748, we find it referred to as the Great Drought, with which the one of that year is to be compared; and it is known that the following spring, 1715, was one of very great suffering, on account of the scarcity of provisions.

Starting in 1720, we have somewhat more reliable statistics, in the diary of the Reverend Thomas Smith, of Portland, the journals of Dr. Holyoke and Dr. Prince, of Salem, Professor Farrar, of Cambridge, and

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Starting in 1720, we have somewhat more reliable statistics, in the diary of the Reverend Thomas Smith, of Portland, the journals of Dr. Holyoke and Dr. Prince, of Salem, Professor Farrar, of Cambridge, and

many other sources. From Smith we learn that, in 1722, there was in July "an exceeding dry time as ever was." In 1724, he said, July 23, "great drought; every thing burnt up." This drought continued a long time and was very general in the vicinity of Boston.

The year 1737, was marked by its excessive dryness. During the summer of this year there was a great scarcity of corn, and many went about begging their neighbors to sell them a quart at any price, to keep them from starvation. In 1738, too, there was a drought in some sections of the country, "in such a manner as the like was never known."

The following spring (1739) was also very dry; there was scarcely any rain for a month. Here we find another series of three years of drought.

With the exception of a slight drought in the fall of 1743, we have no complaints of drought until the summer of 1746, when a rather severe dry spell prevailed from the middle of June until the latter part of August. "Plentiful showers," however, relieved the situation on the 24th of the month.

During the autumn of the next year (1747) there was no water in the streams for grinding, on account of the dry weather; and in 1748 (to show another series of droughts), all accounts concur in saying that the drought was unparalleled in the history of the country, except in 1714. The farmers long remembered the drought of 1748, and from all accounts it seemed to have been as severe as the great drought in 1714. Men were obliged, in many instances, to kill their cattle for the want of food. The suffering during the winter was intense, and scarcely had the spring opened when (April, 1749) an awful drought commenced and drove the farmers almost to despair. At Boston it was recorded, July 4, "never more distressing time for pasture; only one-tenth of a crop of hay." July 18, "Extreme hot dry weather, such as had not been known in the memory of man — so scorching that the creatures can but just live for the want of grass." July 24, "thanksgiving for seasonable and refreshing rains." This summer was followed by such a severe winter, that it was difficult to keep cattle alive, and many were left to take care of themselves by browsing in the woods. Hay was imported from England.

Dry weather began again in July, 1752, and according to Smith's diary seems to have been long continued. Professor John Winthrop's rainfall observations kept at Cambridge, Mass., give the rainfall for August that year as 0.87 in. and that for September, 1.33 in.

In 1754, Smith said, July 1, "I have no grass growing on my mowing ground, and there is no feed on the Neck; the reasons are, the open winter, three weeks drought and the grasshoppers." According to further entries in his diary, the dry spell continued until October 24 when "a great storm filled the earth with water." The rainfall at Cambridge for July was above normal, but August and September were dry, the amount recorded in the latter month being about 0.35 in.

Three years later, 1757, Boston and vicinity experienced a rather severe

drought during May and June. The rainfall at Cambridge for May and June that year was 0.89 and 1.01 in. respectively.

The next three years were wet and cold, but fruitful. The spring of 1758, was so backward that people did not generally begin to plant till the end of May, and the corn spoiled by dampness. In 1760, it was said, on June 26, "there has been but twenty-four hours of hot weather this year."

The drought of 1761 is said by Smith to have been as severe as that of 1749. Very little rain fell from the last of May to the 19th of August when a "storm of rain" relieved the situation. Less than 5 in. of rain fell at Cambridge from June through August and it is probable that most of the 2.49 in. recorded in August, fell on and after the 19th; this would put the rainfall for this eleven-week period at approximately 2.5 in.

This year would doubtless have been long remembered and referred to, as one of the most distressing in the history of farming but for the terrible drought of the next year (1762), which exceeded everything of the kind known in the country. This drought deserves a passing notice.

The winter of 1761–1762, had been long and dreary, and the snow, which began to fall as early as the 3rd of December, constantly accumulated till it was more than five feet in depth on the level. It was a time of deep distress for the poor everywhere. The drought of the previous summer had greatly diminished the supplies of hay, and farmers had depended on getting through the winter by browsing their cattle in the woods. This hope was now cut off by the deep snow. Passing from town to town was out of the question; indeed there was no communication between parts of the same town; and this difficulty continued far into the month of March. Some huge mountains of snow lingered even till the 28th of April. The spring, therefore, was very backward; and this added much to the sufferings of the people, already, it would seem, very great. Nor did the distresses of this memorable year end here. The plowing could not be done in season in the spring, partly on account of the loss of oxen and horses in the winter, partly because of want of hay, which made the few animals which were left almost unfit for work, and partly on account of the lateness of the spring, which crowded all the labors of the farm into a very short time. When at last the corn was planted, millions of worms appeared to eat it up, and the ground must be planted again and again. Thus many fields were utterly ruined. It was time now, in the month of May, for the drought to take its turn in the work of the destruction, and it set in with terrible severity, even before there had been rain enough to settle the ground after the frost. The grass dried up almost as soon as it came out of the earth. In many instances people were obliged to gather what little crops they had in June; and they had so little grass that hay sold for one hundred and twenty pounds a ton. Now fires raged with quenchless fury, spreading fear and dismay in their course, and destroying property to a vast amount. Fields were laid waste, barns and mills were swept away, and families were driven from their houses. As early as the 5th of July there began to be fear of an absolute famine.

There was no considerable rain till the 18th of August, when a plentiful rain remarkably renewed the face of nature. The rainfall at Cambridge from April to September, inclusive, was but 9.88 in.; this is nearly 11.4 in. below a 81-year normal for Cambridge and but 47 per cent. of the normal for these six months. Following is the record of rainfall in inches for these six months, at Cambridge:

April 1.47	July 1.76	Total for six months, 9.88
May 2.13	Aug. 2.74	Normal for six months, 21.27
June 0.89	Sept. 0.89	

It is probable that the rainfall on the Cape was even less, since the normal rainfall for these six months there is less than that of Cambridge.

The succeeding winter was also very trying. Our journalist describes it as being as "severe as any we have had"; that there was "scarce a bushel of corn in the whole eastern country"; "that hay was scarce and sold at one hundred twenty pounds a ton." But although the following summer was very wet, yet we are told that everything was "very plentiful except money." Smith's diary has numerous references to the cold wet conditions during July and August.

Very dry times occurred again in August, 1764, April and August, 1765, July, 1767 and in July and August, 1770. In 1772, we find complaints of drought in the vicinity of Boston. In July pastures were all dried up; there was but very little corn, and all kinds of grain suffered very much. July, 1773, was also very dry, and in 1774, there was little or no rain from the 7th of July to the 17th of August. The pastures looked like winter lands, and very little corn was harvested on account of the drought. This was in the neighborhood of Boston, but the suffering extended as far as Maine.

The next three years were years of plenty and prosperity, and it is a curious fact that the spring of all of them was late and backward, and the winters of 1776 and 1777, were of marked severity, being among the coldest ever known. Smith recorded, May 15, 1777, "the coldest weather and the most backward spring that was ever"; June 30, "cold, very cold; nothing like it through the whole spring; and yet every thing is flourishing except Indian corn"; August 18, "never were there such gardens never such fields, never such pastures, never such a year for every thing"; September 2, "The earth is burdened with its fruits."

In 1778, the winter was unusually severe, but the spring was forward and the weather fine, till July, when a moderate drought set in and lasted until August 6. Droughts of limited extent are noticed in the summers of 1781, 1782 and 1786, but in neither of these years was there much suffering from this cause; for, from 1779 to 1787, there was a succession of favorable seasons, and various crops were remarkably abundant.

The rainfall during the summer months of 1791 and 1792, was considerably below the average, but there were no severe droughts during these years, because the rainfall, although light, was evenly distributed through-

out the summers. From a record kept by Dr. Prince, of Salem, it appears that in 1791, 2.30 in. of rain fell in April, 2.55 in. in May, 2.69 in. in June, and but 1.79 in. in July. These amounts are below the average of those months, and would have led to a severe drought in July, had not the distribution been very general over the month. Again in 1792, the rains for July amounted to only 1.60 in. and for August to but 1.34 in. The rainfall, however, was evenly distributed, and we find accordingly, no notice of any great difficulty from want of rain in that year.

A drought of some severity is recorded in August and September, 1796. In the first of these months there were but two slight showers and not an entire cloudy day, according to the journal of a Dr. Holyoke. July had also been very dry. But little rain fell in June and July of the next year (1797), and except for its general distribution over the month, its small quantity would have occasioned much suffering. The amount in June was but 2.44 in. and in July only 1.65 in.

The outstanding feature of the droughts during the 18th century was the very severe dry spell in 1762. This was without doubt the longest and severest spell of aridity in eastern Massachusetts since the landing of the Pilgrims. Other severe droughts occurred in 1714, 1748, 1749 and in 1761, while dry periods of less severity were reported in 1705, 1707, 1724, 1727, 1737, 1746, 1754, 1774 and 1796. In addition to those named above there were sixteen other years when droughts of short duration, and apparently of local extent, were mentioned.

The next bad drought was in 1805. The latter part of the spring of that year was quite dry, and there was not an entire rainy day from the 16th of May to the 29th of September. In July, it was reported that there were 22 days on which not a cloud was to be seen.

In 1818, no rain fell, according to the journal of Dr. Holyoke, from the 3rd of August till the 7th of September; there was but one entirely cloudy day during the month of August, and only a few days were even partially cloudy.

The spring of 1825 was forward, but the drought in April and May was exceedingly unfavorable for grass. August, too, was reported to have been very dry.

In 1826, the earlier part of the season was remarkably dry, and the water in wells was lower than in 1825. There was no rain in May until the 22nd, and then but little.

Local droughts were reported in August, 1828, when but 0.64 in. of rain fell at Waltham, Mass., and again in June, 1832, August, 1836 and July, 1837 and 1838.

June, 1841, was very dry, but no other general and excessive drought occurred till 1844. That year was almost without parallel in eastern Massachusetts and was marked by its excessive dryness throughout the country. The quantity of rain during the summer months was less than it had been for many years, and, as might be anticipated, the crops suffered very much.

Dry times occurred in September and October, 1846, the spring of 1847, April, 1848 and in April, 1852.

The drought of 1854 was undoubtedly more extensive and more destructive than any of those which had preceded it. It was not confined to New England but was felt in nearly every part of the Union. The loss from this cause alone was estimated at no less than one hundred million dollars. From the 20th of June to the 25th of August rain fell only in slight showers and at long intervals, and in many localities there was none for two whole months. In August the rainfall was less than had been known in any one month for many years. At Waltham it was but 0.57 in., at Boston, 0.38 in., at Cambridge, 0.35 in. and at Lowell only 0.18 in. The rainfall during June, July and August at Waltham, was but 4.60 in.

From this period on we have sufficient rainfall observations in southern New England to make it seem feasible to discuss the annual variation of the rainfall by means of progressive average rainfall diagrams. Previous to this period most of our rainfall information concerns dry spells during the growing season with occasional references to wet years and snowy winters. The earliest observations of rainfall in New England were those which were kept continuously by Professor John Winthrop at Cambridge, Mass., from August, 1749, until April, 1775, and intermittently until May, 1779. By use of these observations supplemented with those of other observers, it has been practicable to obtain a nearly continuous record of the rainfall for the region about Cambridge from 1749 until the present time. Our chronicle accounts of rainfall from 1749–1854, can be to some extent connected with actual observations. Then, too, this diagram will give us some insight into the variation of the annual rainfall for the last one hundred seventy-eight years. (See accompanying diagram.)

The earliest observations of rainfall in New England, as previously stated, are those which were kept continuously by Professor John Winthrop at Cambridge, Mass., from August, 1749 until the day of the Battle of Lexington, in 1775. Professor Winthrop continued his observations for a time at Concord and afterwards at Watertown. Later he returned to Cambridge, but the records for some of the months are missing, and the observations were discontinued in 1779. For the present, an estimate based on the study of the diaries of that period, has been used for the missing months.

No records have been found showing the actual measurements of the rainfall for the years 1780 and 1781, but in the latter year meteorological observations were begun at Ipswich, Mass., by Rev. Manasseh Cutler, who began later, September, 1782, to measure and record the amount of precipitation in the form of rain and snow. This observer, as did Professor Winthrop, gives a description of his rain-gage and the method followed by him in his observations. Both observers appreciated fully the difficulty of securing accurate observations, especially in the winter season, and it seems reasonable to assume that their records are as nearly accurate as those of

more recent times. Unfortunately, Cutler's observations were discontinued at the end of the year, 1783.

A more extended record of the rainfall of this period was evidently made by Rev. Jonathan French, at Andover, Mass., whose diary, though apparently extant, has not been accessible even for the purpose of securing the records of rainfall and other meteorological observations which it contains. Fortunately, portions of the observations are to be found in Abbot's "History of Andover," published in 1829, which contains French's records of rainfall complete for the years 1782–1786, inclusive, and also for the years 1793, 1798, 1800 and 1803.

Another observer who appears to have measured the rainfall carefully at about this period was Professor Samuel Williams. In his "Natural and Civil History of Vermont," written in later years, he presents a table of five years of observations of the rainfall at Cambridge, 1784–1788, presumably kept by him, but as the record simply presents an average of these five years and the details have not come to light, the observations are of little practical value. He does present, however, observations of the rainfall at Rutland, Vt., for the year 1789, which happens to be the only rainfall record in New England for that year that has thus far been found.

In the period from 1792 to 1803, observations are available for Charlestown and Stow, Mass., and, as referred to previously, occasional observations at Andover, Mass; these have been used in lieu of observations at Cambridge. Between 1804 and 1817, the only available records are those at New Haven, Conn., New Bedford, Mass., and Brunswick, Me.* It has been necessary to use these records, making such allowances as were deemed necessary for the difference in geographical location and elevation of the stations.

In 1818, the records at Boston became available and, later on, observations at other places, especially at Waltham, Lowell, Lynnfield and, still later, the records at Cambridge itself.

For the years for which observations are lacking, namely 1780, 1781, 1787, 1788, 1790 and 1791, the average rainfall for the entire period has been substituted for these years in constructing this diagram.

The accompanying diagram shows the progressive average annual rainfall in the vicinity of Cambridge from 1749–1925, and for New Bedford, 1814–1925. The graphs shown were constructed by X. H. Goodnough† in 1913 and with his coöperation brought up to date by the author. The progressive average rainfall has been made by plotting the successive rainfall for three-year periods upon the ordinate representing the last year of the group.

No evidence is shown by the Cambridge record that the rainfall in New England is either increasing or diminishing, nor are there any indications of a regular variation in the annual quantity. C. F. Marvin's study

*There is also the Williamstown, Mass. record beginning in 1816. (Mentioned in *Mo. Weather Rev.*, Dec., 1924, vol. 52, p. 563.)

†Jour. N. E. W. W., Vol. 29, Sept. 1915, p. 252.

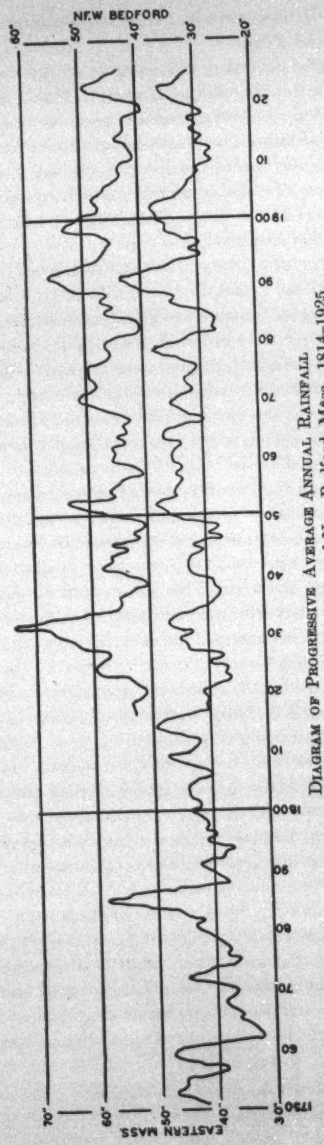

DIAGRAM OF PROGRESSIVE AVERAGE ANNUAL RAINFALL
in Eastern Massachusetts 1749–1925 and New Bedford, Mass., 1814–1925.

of rainfall data, particularly of southern New England*, has led him to conclude that there is no evidence indicating any permanent changes in the climate. His studies demonstrate that more or less definite epochs occur from time to time when the climatic conditions of a more or less limited region suffer a material change in the value of the running average of conditions. So far as the Cambridge record shows, the variations in the annual rainfall are usually short and quite irregular, though the amount may at times remain below or above the average for many years, as in the period from 1832 to 1849, when the amount was almost continuously below the normal, or in the period 1850 to 1863, when it was continuously above it. The periods of continuously high or low rainfall are usually short, averaging from five to seven years.

The most striking of the variations from the normal are the excessive rainfalls in the periods 1783–1785, and 1888–1890, and the great deficiency in 1760–1762. The maximum annual rainfall in the entire one hundred seventy-eight years occurred in 1785 and amounted to 62.40 in. It is interesting to note that one of the greatest and possibly the greatest freshet ever known in the Merrimac River Valley occurred in October, 1785. The rainfall that month recorded at Andover, Mass., was 10.1 in. while the aggregate rainfall for the months of September and October amounted to 19.3 in.

With exception of the excessive rainfalls of 1783–1785 and 1888–1890, occurring almost exactly one hundred years apart, the maximum rainfall in the region of Cambridge has never equalled an average of 50 in. for a three year period, and, with the two exceptions indicated, a maximum of 48 in. for three years has been reached but five times, though in four other periods the maximum has exceeded 47 in.

In the period of three years of lowest rainfall, 1760–1762, the average amount fell to a little over 32 in., and the rainfall for the minimum year, 1762, amounted to 24.47 in. The dry period, however, extended almost continuously from 1760 to 1775 and probably included a few subsequent years. While the lowest rainfall for three years occurred in 1760–1762, the rainfall in several subsequent groups of years was also very low, as for example from 1761–1763, with an average of 32.59 in.; 1773–1775, with an average of 35.77 in., and 1764–1766 with an average of 35.80 in.

In no other group of years are the rainfalls as low as in the years 1760–1775, nor has the minimum annual ever been lower than that recorded by Professor Winthrop in 1762. Next in order of dryness is the period 1820–1826, in which the minimum three year group was 1820–1822, with an average rainfall of 36.09 in., while the rainfall for the minimum year, 1822, amounted to 27.2 in. Other three-year groups in which the average rainfall was over 36 but under 37.5 in., are, in descending order, 1792–1794, 1844–1846, 1908–1910, 1881–1883, 1882–1884, 1910–1912 and 1835–1837.

The average rainfall in the vicinity of Cambridge for the whole period

* C. F. Marvin, concerning normals, secular trends and climatic changes. *Mo. Weather Rev.*, Aug., 1923, vol. 51, pp. 383–390. See esp. Figs. 1 and 2.

from 1749–1925, inclusive, computed from records, compiled in the manner described, is 42.27 in. and the average for the forty-five years, 1881–1925, is 42.57, or less than one per cent. higher than the average for the entire one hundred seventy-eight years. This difference, under the circumstances, is insignificant. The rainfall for the minimum year, as already indicated, was 24.47 in. and for the maximum, 62.40 in. In the forty-five years under discussion the rainfall in the minimum year was 30.13 in., and in the maximum 56.23 in.

At New Bedford the periods of maximum and minimum were, with a few exceptions, similar to those of Cambridge. The greatest average rainfall for three consecutive years at New Bedford occurred in 1829–1831, when the average precipitation amounted to 63.7 in. During this same period the average precipitation in the vicinity of Cambridge was but slightly over 46 in. This is considerably more than the normal difference in the annual precipitation between these two stations. An examination of the monthly records of the two stations for these years indicate that most of this apparent discrepancy may be accounted for by the local character of the summer rainfall, but it seems more than a coincidence that this should happen during three consecutive summers.

Next in order comes the three year period 1888–1890, with an average rainfall of 56.5 in.; then the periods 1896–1898 and 1850–1852 when the averages were 53.6 and 53.5 in., respectively.

The minimum rainfall for any three consecutive years shown by this record occurred in 1916–1918, when the average amount falling was 39.30 in., with a value in the minimum year, 1918, of 32.90 in. The next lowest rainfall occurred in 1836–1838 with an average of 40.1 in. The three year periods of 1917–1919, 1855–1857, and 1880–1882 all averaged very close to 40.5 in., while that of 1908–1910 averaged 40.8 in.

The periods of maximum and minimum rainfall are somewhat more sharply defined than those in the vicinity of Cambridge and it has been possible to prepare a table of yearly rainfalls divided into quite definite periods of maximum, minimum and average rainfall which shows the approximate periodic variations at this station for one hundred twelve years. The average length of the periods is from seven to eight years, according with the widely discussed weather periods of this length. These periods and the average amounts of rainfall in each are here presented in tabular form.

Although the period of lowest rainfall occurred in 1844–1849, as shown by the table, the period 1905–1918 is perhaps the most significant since it includes a greater number of years, has the minimum rainfall for any three consecutive years and the absolute minimum annual rainfall for the entire one hundred twelve years, as previously referred to.

The average annual rainfall at New Bedford for the one hundred twelve years covered by observations was 46.18 in. and for the last forty-five years given, 46.03 in. The maximum rainfall for the entire period was

PERIODS OF MAXIMUM AND MINIMUM ANNUAL RAINFALL, NEW BEDFORD, MASS.

ARRANGED IN ORDER OF OCCURRENCE.			ARRANGED IN ORDER OF MAGNITUDE.		
Period.	Number of Years.	Average Rainfall. In. per Year.	Period.	Number of Years.	Average Rainfall. In. per Year.
1814–1822	9	42.28	1844–1849	6	41.06
1823–1832	10	54.26	1905–1918	14	41.88
1833–1839	7	42.79	1923–1925	3	42.30
1840–1843	4	47.48	1879–1885	7	42.59
1844–1849	6	41.06	1833–1839	7	42.79
1850–1854	5	50.74	1855–1866	12	43.23
1855–1866	12	43.23	1891–1895	5	45.69
1867–1878	12	48.91	1840–1843	4	47.48
1879–1885	7	42.59	1867–1878	12	48.91
1886–1890	5	54.22	1919–1922	4	48.79
1891–1895	5	45.69	1896–1904	9	49.45
1896–1904	9	49.45	1850–1854	5	50.74
1905–1918	14	42.88	1886–1890	5	54.22
1919–1922	4	48.79	1823–1832	10	54.26
1923–1925	3	42.30			

65.41 in., in the year 1829, and the minimum rainfall, 32.90 in., in 1918. During the last forty-five years of record, the maximum rainfall was 62.60 in., in 1898, and the minimum, 32.90 in., in 1918.

The variation in amount of annual rainfall at many other stations in both northern and southern New England, are similar to those noted at Cambridge and New Bedford.

Judging from a comparison of available rainfall records for the ninety-three years from 1833–1925, the year 1846 was by far the driest recorded throughout a large part of New England, while the years 1863–1864, 1893–1894 and 1908 were also noted for their dryness throughout a greater portion of this area.

The conditions affecting the distribution of rainfall appear to act quite uniformly throughout the greater part of New England, and a year of deficient rainfall which affects seriously a portion of the area usually affects the greater part of it, but there is considerable variation in the distribution of rainfall even in very dry years. For purpose of comparison, the period 1876–1925 may be used, since records in northern New England were too limited to justify a comparison for a longer period. During this period the year 1880 was probably the driest in a considerable area of central and southern New Hampshire and a small portion of Vermont; it was also probably the driest year in small portions of western Connecticut. The year 1883 was one of severe drought in parts of central and southeastern Massachusetts and in the Connecticut River Valley in Connecticut, while the year 1894 was probably the driest recorded in certain sections of northern Connecticut, western Massachusetts, the southern part of New Hampshire and Vermont and along most of the Maine coast. The year 1914 was the driest year in the interior and northern parts of Maine, while 1918

was a very dry year in most of southeastern Massachusetts and Rhode Island. In other sections the precipitation of 1908 and 1910 was lower than any other in the last fifty years of record.

Summary.

This study as a whole shows that, so far as it is possible to judge from available records, which cover at the longest a period of one hundred seventy-eight years, there are no indications that a notable increase or decrease is taking place in the rainfall of New England, nor is there any marked evidence of material change in its seasonal distribution.

As to the occurrence of periodic variations of considerable length, the available records do not appear to furnish a reliable basis for definite conclusions. As a rule, the amount of the rainfall fluctuates frequently, with little apparent regularity, and the periods of high or low rainfall rarely continue for fifteen years, while their average duration is from five to eight years.

THE RAINFALL OF NEW ENGLAND.

ANNUAL RAINFALL.*

BY J. HENRY WEBER.†

The only previous work dealing with the rainfall of New England in any detail is that of X. H. Goodnough in 1915[1]. Mr. Goodnough, who is the Chief Engineer of the Massachusetts Department of Public Health, has collected all rainfall data that have hitherto been published in the reports and bulletins of the U. S. Weather Bureau, the New England Meteorological Society, the reports of water departments of cities and towns and the annals of academies and colleges. In addition many records were found in other publications and a few were obtained from original manuscripts that hitherto had not been made public. All these data were published in the JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION, September, 1915[2], and brought up to date in September, 1921[3], and June, 1926[4]. In addition to presenting tables of the rainfall of 241 New England stations in the 1915 publication, Mr. Goodnough has presented valuable information concerning the historical observations of rainfall in New England, two diagrams showing the progressive average rainfall over a long period of years in Massachusetts, average monthly rainfall diagrams for the principal watersheds in the area and a map and discussion of the mean annual rainfall of New England. This mean annual rainfall map was based mainly on records covering a period of 40 years, 1873–1913. The isohyets were drawn for every two inches. Areas of higher rainfall are shown in western Massachusetts and Connecticut, central Massachusetts, the Narragansett Basin and the White Mountain district. Only in western Connecticut and in the White Mountain district are amounts above 50 in. indicated. The Champlain Lowlands, the north central portion of Vermont and the northern portion of the Kennebec River Valley, are the principal areas of low rainfall shown. In these regions the amounts are below 36 in., with the lowest rainfall, 30 in., in the northwestern portion of Vermont. No attempt was made to indicate the mean annual rainfall in northern Maine.

Data Utilized. The data used in the present study were compiled from Mr. Goodnough's tables, with a few additions from Bulletin W[5] and Climatological Data[6].

Records were tabulated for 313 stations in New England and for 22 stations in the adjoining regions of New York, Quebec and New Brunswick for the period, 1881–1925, inclusive. These stations and the number of years of record are shown in Table 2.

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* Editor's Note: Previously printed in this JOURNAL, Vol. XLII, No. 2, June, 1928, pp. 137–149.
†Clark University, Worcester, Mass.

Individual missing months in these records were supplied through interpolation of the values of one or more nearby stations for the month in question, although in a few cases missing values were supplied by direct substitution of the values of a nearby station. Stations thus completed, with from 3 to 44 years of record, falling within the 1881–1925 period, were adjusted to a 45-year basis by establishing ratios for the missing years[7]. In a few instances adjustments were not deemed feasible and the original values were used without change. In other instances adjustments were made on stations reporting for less than 45 years. In nearly all of the above mentioned cases, however, the stations in question had reported during at least 35 of the 45 years.

The data thus made available for mean values are summarized in Table 1.

TABLE 1.

NUMBER OF RAINFALL STATIONS AND LENGTH OF RECORD.

(Forty-five-year period, 1881–1925, Inclusive.)

	Length of Record — Years.						Total.
	45	35–44	25–34	15–24	5–14	Under 5	
Maine	5	3	5	10	10	5	38
New Hampshire	5	3	8	8	13	1	38
Vermont	2	3	6	5	14	2	32
Massachusetts	24	14	26	16	74	1	155
Connecticut	6	7	5	3	8	0	29
Rhode Island	2	6	0	2	6	0	16
New York	2	2	5	2	0	0	11
Quebec	2	1	0	1	1	0	5
New Brunswick	1	0	1	0	4	0	6
Total	49	39	56	47	130	9	330

There were also five additional stations, all in northern New England, that were tabulated and used in some cases for maximum and minimum annual values.

Acknowledgments. The writer wishes to express his indebtedness to Dr. Charles F. Brooks, under whose direction the work was done, and to the Graduate School of Geography at Clark University.

MAPS OF ANNUAL RAINFALL AND THEIR INTERPRETATION.

Mean Annual Rainfall (Plate I). The greater portion of New England has a mean annual rainfall (including melted snow, sleet, and hail) of between 40 and 45 in. The mean values for stations with 45 years of record vary, however, from 47.29 in. at Canton, Conn., to 31.78 in. at Burlington, Vt.; stations with shorter records indicate values varying from 82.21 in. at Mount Washington, N. H., (16–20-year record unadjusted) to the adjusted value of 29.1 in. at Houlton, Me. (See Table 2.)

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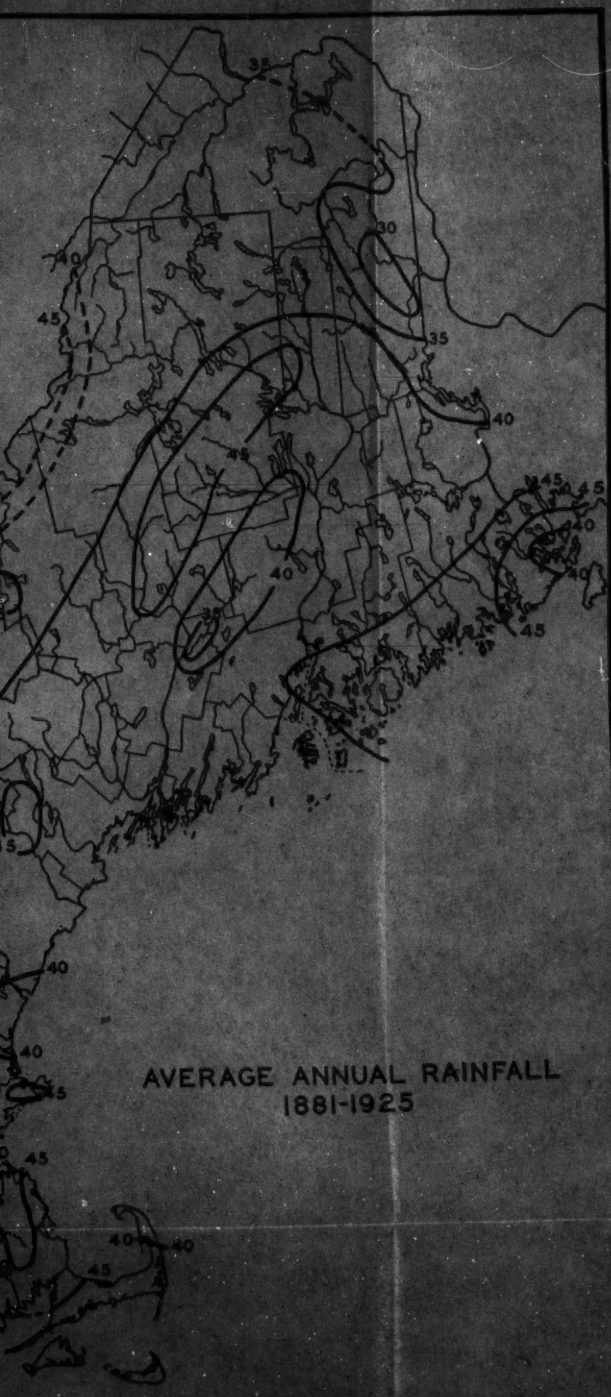
PLATE I.
N. E. W. W. ASSOCIATION.
VOL. XLIV.
WEBBER ON
RAINFALL OF
NEW ENGLAND.



ADAPTED FROM MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH'S MAP OF NEW ENGLAND - K.M. GOODNOUGH, CHIEF ENGINEER
DRAWN BY G. HUGHES WEBBER, CARTOGRAPHER, GRADUATE SCHOOL OF GEOGRAPHY, CLARK UNIVERSITY, WORCESTER, MASS.

TABLE 2.

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Maine.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Ashland	...	4	34.8	Houlton
Azischos Dam	...	15	36.8	Upper Dam
Bar Harbor	20	35	49.0	Eastport
Belfast	165	13	45.1	Portland
Calais	120	13	47.7	Eastport
Camden	...	12	42.4	Portland
Cornish	778	43	46.86	None
Danforth	390	8	40.0	Orono
Eastport	53	45	38.94	....
Fairfield	90	30	34.4	Gardiner
Farmington	450	35	43.5	Gardiner
Flagstaff	1 400	15	36.7	Upper Dam
Gardiner	163	45	42.36	....
Greenville	1 000	20	45.5	Orono
Houlton	362	21	29.1	Fredericton, N.B.
Jackman	...	4	38.3	Upper Dam
Kineo	1 060	4–9	34.0	Mayfield
Lewiston	185	45	43.47	....
Livermore	338	15	43.0	Lewiston
Madison	257	24	46.1	Gardiner
Mayfield	1 000	15	46.7	Orono
Middle Dam	1 430	21	35.1	Upper Dam
Millinocket	129	26	44.0	Orono
Milo	...	4	39.4	Orono
N. Bridgton	450	32	44.9	Lewiston
Old Town	95	12	42.3	Orono
Oquossoc	1 534	9	38.9	Upper Dam
Orono	129	45	41.24	....
Patten	550	16	40.3	Orono
Portland	99	45	42.33	....
Presque Isle	1 000	12	36.2	Fredericton, N. B.
Rumford Falls	505	32	41.1	Lewiston
Songo	280	10	42.5	Portland
The Forks	580	14	40.6	Orono
Upper Dam	1 470	40	32.78	None
Van Buren	510	17	36.9	Fredericton, N. B.
Winslow	90	30	38.5	Gardiner
Woodland	...	6	43.6	Eastport
Wytopitlock	...	8	40.3	Orono

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

New Hampshire.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Alstead	1 120	29	40.0	Hanover
Belmont	600	12	40.0	Lakeport
Berlin	...	15	37.0	Errol
Berlin Mills	1 100	25	37.6	Errol
Bethlehem	1 470	33	38.4	Hanover.
Bristol	600	9	41.5	Lakeport
Brookline	250	26	42.4	Fitchburg
Concord	350	45	37.36	....
Durham	88	31	40.4	Lawrence
Errol	1 260	41	37.49	None
Fitzwilliam	1 110	6	45.4	Fitchburg
Franklin	440	24	42.1	Concord
Glencliff	1 650	16	42.9	Plymouth
Gorham	...	15	34.6	Errol
Grafton	863	36	38.3	None
Hanover	603	45	34.91	....
Keene	506	34	38.2	Fitchburg
Lakeport	500	45	42.14	....
Littleton	1 032	8	38.8	Plymouth
Manchester	200	45	39.21	....
Mt. Washington	6 293	16–20	82.21	None
Nashua	125	42	39.33	Lowell
Newton	200	29	40.0	Lawrence
North Conway	575	13	41.2	Cornish
Peterboro	744	11	40.4	Fitchburg
Pittsburg (a)	1 575	8	40.8	Errol
Pittsburg (b)	1 575	8	45.0	Errol
Plymouth	500	45	40.29	....
Profile	...	4	50.9	Plymouth
Sanbornton	830	10	37.7	Lakeport
Stratford	1 000	21	36.6	Errol
Weirs	500	16	40.5	Lakeport
West Milan	1 016	11	40.0	Errol
West Stewartstown	1 050	12	31.2	Errol
Wolfeboro	500	16	41.9	Lakeport
Woodstock	1 050	8	48.0	Plymouth
Woodville	750	8	34.9	Hanover

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Vermont.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Bellows Falls	300	12	35.0	Hanover
Bennington	720	3	40.8	Williamstown
Bloomfield	900	19	36.9	Errol
Brattleboro	335	15	40.9	Amherst
Burlington	404	45	31.78	....
Cavendish	910	22	38.4	Woodstock
Chelsea	840	40	35.57	None
Cornwall	507	39	31.2	Burlington
Enosburg Falls	601	34	39.4	Burlington
Fitzdale	850	7	30.3	St. Johnsbury
Garfield	1 300	6	40.1	Northfield
Guildhall	875	12	32.4	St. Johnsbury
Halifax	900	12	40.9	Williamstown
Hyde Park	576	6	38.9	Northfield
Jacksonville	1 000	28	44.4	Williamstown
Londonderry	1 000	12	36.1	Williamstown
Manchester	980	15	41.1	Williamstown
Morrisville	690	3	....	....
Northfield	876	38	32.94	None
Norwich	550	32	37.2	Hanover
Readsboro	1 220	9	48.0	Williamstown
Ryegate	480	12	33.6	St. Johnsbury
St. Johnsbury	711	32	34.87	None
Somerset	2 096	14	52.5	Williamstown
Strafford	500	17	38.9	Woodstock
Vernon	310	32	40.2	Amherst
Victory	800	4	38.0	St. Johnsbury
Wells	750	27	38.5	Williamstown
West Hartland	665	14	39.6	Hanover
West Rutland	562	9	33.4	Cornwall
White River Jct.	400	12	33.3	Hanover
Wilmington	1 500	7	47.4	Williamstown
Woodstock	700	45	38.12	....

Massachusetts.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Acushnet	50	45	46.73	....
Agawam	410	12	49.0	Springfield
Amherst	222	45	43.69	....
Ashby	1 000	11	46.5	Fitchburg
Ashland	250	36	43.44	Westborough
Athol	1 000	14	40.3	Fitchburg
Attleborough	100	25	44.7	Taunton
Barre	930	6	45.2	Princeton
Bedford	170	31	39.6	Concord
Belchertown	440	16	41.4	Ludlow
Blue Hill (Summit)	640	40	46.23	Chestnut Hill

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Massachusetts (Continued).

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Blue Hill (Valley)	60	33	44.4	Chestnut Hill
Boston	124	45	39.53	....
Boylston	530	30	46.3	Clinton
Bridgewater	60	11	45.0	Taunton
Brockton	200	32	40.73	Taunton
Cambridge	75	45	41.68	....
Charlton	880	5	42.4	Webster
Chester	600	13	44.6	Canton, Conn.
Chesterfield	1 360	6	46.2	Pittsfield and Amherst
Chestnut Hill	124	45	45.25	....
Clinton	300	45	42.76	....
Cohasset	50	8	46.8	Hingham
Colrain	500	13	44.2	Williamstown
Concord	139	35	40.9	Waltham
Cotuit	60	8	42.1	New Bedford
Cummington	1 400	6	46.7	Pittsfield and Amherst
Dalton	1 200	20	42.9	Pittsfield
Dana	580	5	45.4	Leicester
Danvers	100	14	41.6	Wenham
Deerfield	140	5	44.1	Amherst
Dudley	450	34	42.8	Webster
Easthampton	200	9	53.0	Amherst
Egremont	750	19	43.3	Pittsfield
Fall River	210	45	45.22	....
Falmouth	70	7	45.4	New Bedford
Fitchburg	625	45	41.88	....
Framingham	160	45	43.88	....
Gardner	1 100	19	45.5	Fitchburg
Gilbertville	560	8	49.3	Leicester
Gloucester	40	11	47.1	Lynn
Granville (a)	750	13	47.4	Canton
Granville (b)	950	12	52.6	Canton
Greenwich	490	6	46.6	Amherst
Groton	325	36	42.0	Fitchburg
Hardwick	950	5	42.9	Leicester
Haverhill	125	31	40.5	Lawrence
Heath	1 650	6	47.1	Williamstown
Hingham	70	40	45.02	Chestnut Hill
Holden	750	40	45.00	Leicester
Holyoke	90	28	47.1	Springfield
Hubbardston	1 030	6	42.6	Princeton
Huntington	500	6	47.3	Canton, Conn.
Hyannis	31	34	43.5	New Bedford
Ipswich	30	14	45.9	Wenham
Lakeville	60	32	45.32	Taunton
Lawrence	51	45	41.30	....
Leeds	350	20	47.65	Amherst
Leicester	800	45	43.63	....
Leominster	500	41	43.37	Fitchburg
Littleton	325	8	37.6	Clinton
Lincoln	187	20	39.0	Waltham
Lowell	100	45	43.78	....
Ludlow	410	45	41.44	....
Lynn	40	45	41.03	....
Manchester	20	13	42.6	Lynn
Mansfield	150	11	48.6	Taunton

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Massachusetts (Continued).

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Marlborough	450	26	41.5	Framingham
Medford	17	10	41.9	Waltham
Middleboro	53	38	43.9	Taunton
Middlefield	1 650	5	43.0	Pittsfield
Milford	275	11	41.1	Northbridge
Millis	130	5	42.8	Natick
Monroe Bridge	840	12	44.9	Williamstown
Monson	370	27	43.0	Springfield
Mount Nonotock	850	10	43.8	Springfield
Mt. Wachusett	2 000	...	50.2	Princeton
Nantucket	47	39	40.31	Block Island, R. I.
Natick	140	45	43.35	....
New Bedford	88	45	46.03	....
Newburyport	20	22	38.0	Lynn
Newton	100	18	42.1	Waltham
New Salem	850	6	44.6	Princeton
Norfolk	244	18	43.7	Natick
North Adams	1 000	26	43.4	Williamstown
North Andover	100	14	40.8	Lowell
North Billerica	100	20	41.3	Lowell
Northbridge	350	45	44.85	....
North Dana	520	6	44.0	Leicester
Norwood	90	13	42.6	Natick
Otis	1 400	13	45.5	Canton, Conn.
Peabody	75	14	44.1	Lynn
Pembroke	65	10	44.4	Taunton
Peru	1 700	13	45.9	Pittsfield
Petersham	1 100	10	45.0	Fitchburg
Phillipston	1 190	5	42.6	Fitchburg
Pittsfield	1 050	31	41.8	Williamstown
Plainfield	1 650	6	47.5	Pittsfield
Plymouth	50	39	45.97	Taunton
Prescott	1 000	10	45.2	Amherst
Princeton	1 125	37	45.10	Princeton
Provincetown	40	34–39	38.94	None
Quincy	20	13	43.2	Chestnut Hill
Reading	80	27	42.8	Wenham
Rochester	60	27	48.3	Acushnet
Rockport	30	23	43.1	Lynn
Rowe	1 300	8	42.9	Williamstown
Rutland	1 160	18	44.3	Leicester
Salem	20	25	41.2	Lynn
Savoy	2 000	13	47.3	Williamstown
Sharon	270	22	44.1	Natick
Shelburne Falls	300	11	40.2	Amherst
Shutesbury	1 175	6	49.0	Princeton
Somerset	40	38	44.33	Fall River
Somerville	60	17	42.3	Cambridge
Southampton	250	29	48.3	Amherst
Southboro	525	32	46.09	Westborough
Southbridge	720	14	43.9	Webster
Springfield	200	45	42.51	....
Sterling	500	29	43.0	Leicester
Stockbridge	875	6	42.6	Pittsfield
Stoneham	160	27	43.6	Waltham
Sturbridge	600	11	39.3	Webster

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Massachusetts (Continued).

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Taunton	50	45	47.67	....
Templeton	930	29	39.8	Fitchburg
Turners Falls	200	34	39.5	Amherst
Vineyard Haven	40	6	42.3	Block Island
Wakefield	100	8	42.9	Lynn
Walpole	90	24	41.7	Natick
Waltham	20	45	42.68	....
Ware	520	6	41.6	Leicester
Wareham	60	8	45.5	New Bedford
Warren	650	11	40.6	Leicester
Warwick	1 000	5	45.6	Princeton
Webster	450	45	42.83	....
Wellesley	160	8	44.8	Natick
Wendell	1 200	6	44.6	Princeton
Wenham	60	45	42.15	....
Westborough	298	45	43.97	....
West Brookfield	630	13	41.0	Leicester
Westfield	475	20	49.5	Canton
West Granville	1 200	13	48.5	Canton
Westhampton	750	7	48.1	Springfield
Westminster	880	11	49.4	Fitchburg
Weston	60	36	43.4	Waltham
West Roxbury	185	14	43.2	Boston
West Ware	450	6	41.8	Leicester
Williamsburg	550	13	43.6	Amherst
Williamstown	711	45	37.83	....
Winchendon	975	32	42.4	Fitchburg
Winchester	90	32	40.0	Waltham
Woods Hole	22	13	41.0	New Bedford
Worcester	400	30	40.78	Leicester
Worthington	1 500	9	46.8	Pittsfield
Wrentham	250	5	46.5	Taunton

TABLE 2 (Continued).

THE MEAN ANNUAL RAINFALL OF STATIONS IN NEW ENGLAND.

Connecticut.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Bridgeport	20	32	47.38	New Haven
Burlington (a)	497	8	46.4	Canton
Burlington (b)	693	7	51.1	Canton
Canton	900	45	47.29	....
Colchester	370	34	49.5	Norwich
Cream Hill	1 300	29	46.6	Canton
Danielson	300	14	45.0	Hope
Enfield	90	10	44.7	Springfield
Fall Village	600	35	43.79	Canton
Greenwich	...	41	43.63	New Haven
Hartford	159	45	44.00	....
Hartland	1 200	9	51.6	Canton
Lake Konomoc	180	12	45.9	New London
Mansfield	640	20	44.2	Hartford
Middletown	125	45	46.63	....
Nepaug	690	13	48.1	Canton
New Hartford	399	13	46.1	Canton
New Haven	127	45	44.88	....
New London	47	45	43.58	....
Newtown	600	17	47.1	Boyds Corner, N. Y.
No. Grosvenordale	400	35	44.4	Webster
Norwalk	116	34	46.12	New Haven
Norwich	150	45	42.64	....
Simsbury	300	23	44.0	Canton
Southington	140	40	43.25	Middletown
Torrington	625	16	47.0	Canton
Voluntown	260	39	46.32	Norwich
Wallingford	130	35	47.20	Middletown
Waterbury	400	39	47.27	Middletown

Rhode Island.

Station.	Elevation. (Feet.)	Number of Years of Record.	Mean Annual Rainfall. (Inches.)	Station on which adjusted.
Block Island	26	45	41.21	....
Bristol	53	39	41.88	Fall River
Cranston	260	9	47.5	Providence
Foster	450	10	48.4	Providence
Greene	450	15	46.7	Voluntown
Hope	200	38	48.32	Providence
Hopkinton	120	10	50.8	Norwich
Kingston	250	37	52.14	New London
Lonsdale	116	19	45.7	Providence
Narragansett Pier	22	36	46.23	New London
Pawtucket	90	41	46.04	Providence
Providence	162	45	46.96	....
Scituate	440	10	46.2	Providence
South Scituate	280	10	48.0	Providence
Wallum Pond	40	8	44.7	Webster
Woonsocket	160	40	47.05	Providence

An area of higher rainfall, over 45 in., extends from the neighborhood of the Croton watershed in eastern New York State into Connecticut whence it divides into two branches. One extends eastward to the Massachusetts coast and the other continues north and northeastward to southern Vermont and New Hampshire. In the eastern branch a small area in southern Rhode Island is enclosed by the 50-in. isohyet, where damp southerly winds strike the hills in an unobstructed sweep from the ocean. In the northern branch there are a number of wet spots, each of which, however, is smaller in extent than that of Rhode Island.

The coast of Rhode Island is not protected, as is the coast of Connecticut by Long Island. This condition is sufficient to account for a greater rainfall in southern Rhode Island, for here, particularly in the colder season, muggy southerly winds blowing freely off the ocean are forced upward, chilled, and made to yield more of their moisture than elsewhere along the coast. Here, owing to friction with the land, they lose velocity on coming ashore, and crowd upward. The rise of a few hundred feet directly back of the coast accentuates this process, as does also the usual cushion of cold air over the land. Inland a little way, there is no notable further increase in elevation, so the maximum rainfall is soon reached. For example, Narragansett Pier has a mean annual rainfall of 46.23 in., Kingston, seven miles inland, reports 52.14 in., and Hope, eighteen miles north of Kingston, has 48.32 in. A similar, but less marked condition, is indicated in southern Massachusetts and Connecticut.

In the northern branch the areas having a mean annual rainfall over 50 in. are at a considerable distance inland, and at relatively higher elevations, varying from 700 ft. in Connecticut to 2 000 ft. in southern Vermont. A record kept at the northern base of Mount Tom, in the Connecticut River Valley of Massachusetts, indicates a mean annual rainfall of 53 in. Heavier rainfall occurs here, particularly in the summer months, as the southerly winds give up abundant moisture in their forced ascent of Mount Tom. Bar Harbor, Me., at the northeastern base of Mount Desert, indicates a similar condition, except that the heavier precipitation comes in the winter months.

Except in the southern portion, observations are lacking in the higher portions of the Green Mountains, in Vermont. In the south there is a mean annual rainfall of over 50 in. at the higher elevations, but it is probable that the northern and central portions do not experience a mean annual rainfall of 45–50 in. except at the very highest elevations. This is because of a greater distance inland, higher latitude and the rain shadowing by the Adirondack Mountains and the White Mountains.

As far as observations show, the White Mountain district is the only other area in New England with a mean annual rainfall of 50 in. or over. Here, as in the Green Mountains, the number of stations are few, Mount Washington being the only rainfall station above 1 500 ft. elevation. This station, however, clearly shows the increase of rainfall with altitude, a

16–20-year record here indicating an average rainfall over 80 in. It is probable that most of the higher elevations in the White Mountains have a rainfall, similar to, though not so great as, that of Mount Washington.

The effect of elevation on the rainfall is again shown in the higher rainfall in the highlands of central and southwestern Maine and in the mountains along the New Hampshire, Maine and Quebec boundaries. Bar Harbor, Me., has a much higher rainfall than elsewhere in the region (49 in.), and it is possible that this area of higher rainfall might include the highlands east of Bangor, Me.

The most outstanding areas of lower rainfalls are the Lake Champlain lowlands, northeastern Maine and the Connecticut Valley and adjoining area in central Vermont. All these areas have a mean annual rainfall under 35 in. The Champlain lowlands are in the rain-shadow of the Adirondacks and Green Mountains; the Connecticut Valley region is in the rain-shadow of the Green and White Mountains. In the former area the lowest on the Vermont side is 31.2 in., at Cornwall, although in the adjoining region of New York State the mean annual amount falls below 30 in.; in the latter area the lowest is 32.2 in. at Northfield, Vt. In the Maine region a small area, Houlton, has under 30 in. of rainfall with a mean of 29.1 in., having the lowest mean annual rainfall in New England.

There are two small areas to the northeast of the higher elevation of the White Mountains, with a rainfall under 35 in., on the average; both are rain-shadows. In the northern portion of the Kennebec Valley in Maine and the southeastern portion of the Merrimack Valley and adjacent watersheds draining towards the coast, the rainfall diminishes considerably from the amount recorded in the surrounding areas. Only in the former area, however, does the average amount drop below 35 in.

The effect of the upwelling of cold water along the coast of Maine in reducing the precipitation, particularly in the summer months, is clearly shown at Eastport, where the mean annual amount falls below 39 in.; this is considerably lower than in the adjoining area. In the Narragansett Basin, on Cape Cod and on the islands of Martha's Vineyard, Nantucket and Block Island, water again plays its part in reducing the annual precipitation; in these regions, as at Eastport, the contiguous water bodies hinder the development and maintenance of convectional storms that play such an important rôle in the warm season rainfall. Bristol, on a peninsula in Narragansett Bay, has a mean annual rainfall of 41.9 in., while Kingston, eighteen miles to the south-westward, and Hope, fifteen miles to the westward, have 52.1 and 48.3 in., respectively. From the vicinity of the Cape Cod Canal to Provincetown the rainfall decreases more than 9 in. For instance, at Rochester, the mean annual amount is 48.3 in., at Hyannis, near the center of Cape Cod, 43.5 in., while at Provincetown the amount falls to 38.9 in.

The variation in the mean annual rainfall in the Boston Basin and vicinity is considerable. At Boston the weather-bureau station indicates

a mean annual rainfall of 39.53 in., at Cambridge the amount is 41.68 in. and at Chestnut Hill, Brookline, 45.23 in. The greater distance from the cold harbor and the slight rise in the land to the west of Boston, seem sufficient to account for the greater rainfall at Chestnut Hill, although the poor location of the Boston rain-gage on the roof of the Post Office building, may be an additional factor. On the summit of Blue Hill, elevation 640 ft., the annual rainfall, 46.2 in., is nearly two inches higher than the 44.4 in. at the base, elevation 60 ft.

Absolute Maximum Annual Rainfall (Plate II). The greater portion of New England has at some time during the period of record experienced an annual rainfall between 55 and 60 in., and all portions, with the exceptions of the Champlain lowlands, northeastern Maine and the Connecticut Valley in northern Vermont and New Hampshire, have recorded over 45 in. It will be noted that these same three areas have the lowest mean annual rainfalls in New England. In the first-named area, Cornwall reports its highest as 41.9 in., Houlton, in the second-named area, as 40.4 in., and St. Johnsbury, Vt., in the last-mentioned region, as 43.9 in. All of these stations have reported for less than the 45-year period under consideration, but examination of nearby stations seems to indicate that these values should be the maxima for the entire period. The maximum at each short-record station was compared with that of the nearest long-record station. If the year of greatest rainfall was the same for both stations then the maximum at the short-record station was taken as its maximum for the entire period. If, on the other hand, the year of greatest rainfall at the long-record station occurred before or since records existed at the shorter-record station, the difference between the maximum at the short-record station and the value recorded for the same year at the long-record station, was added or subtracted, as the case may be, to the absolute maximum amount recorded at the long-record station. This value was used as the probable maximum for the entire period at the short-record station.

The greatest annual rainfall recorded anywhere in this region is 121.13 in. at Mount Washington. In fact only one other station during the period covered by this study has ever recorded over 70 in., Kingston, R. I., reporting 72.2 in. An examination of all available earlier records in New England reveals that apart from the two stations mentioned, Brunswick, Me., is the only one to have over 70 in. of rainfall in a year; in 1845, 75.6 in. was recorded at this station. The general distribution of absolute maximum annual rainfall is in general accord with that of the average annual.

In southern New England, Provincetown, a place of low average rainfall, is the only station not to have recorded 50 in.

Absolute Minimum Annual Rainfall (Plate III). The annual rainfall has at some time during the period of record fallen below 40 in. at all stations with appreciable record with the exceptions of Mount Washington and Kingston, while the greater portion of the area has experienced under 30 in.

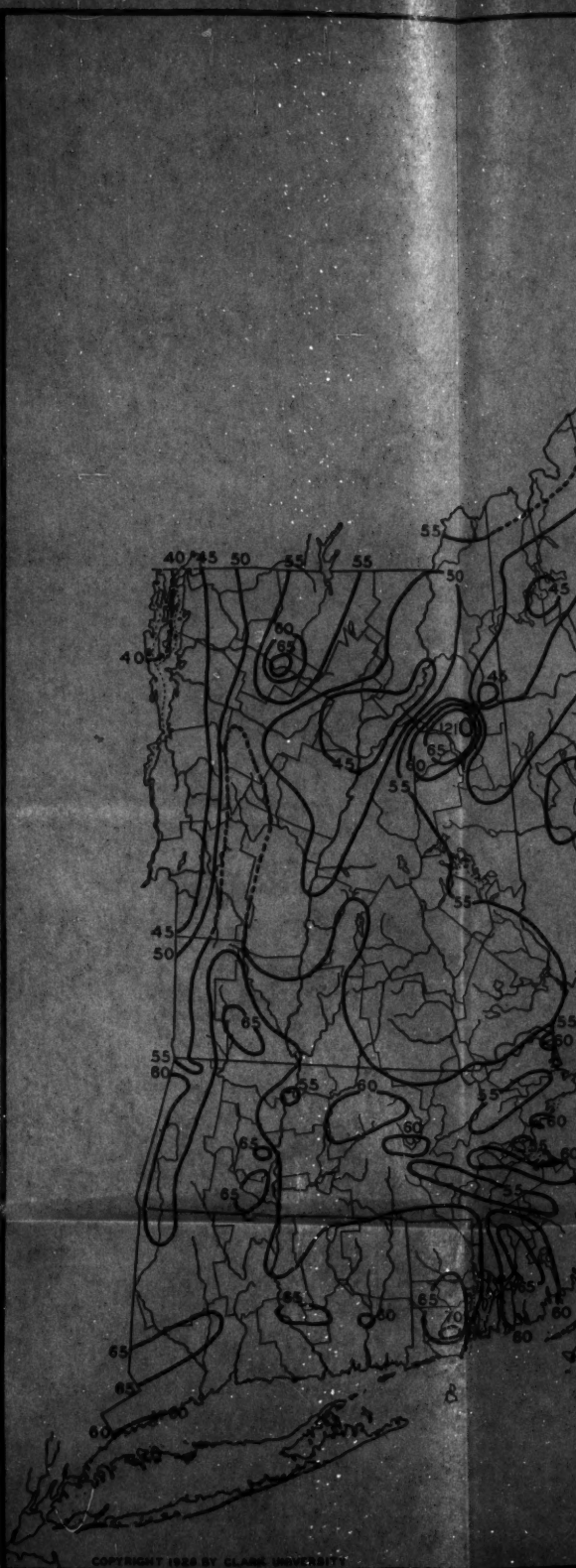

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PLATE II.
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WEBBER ON
RAINFALL OF
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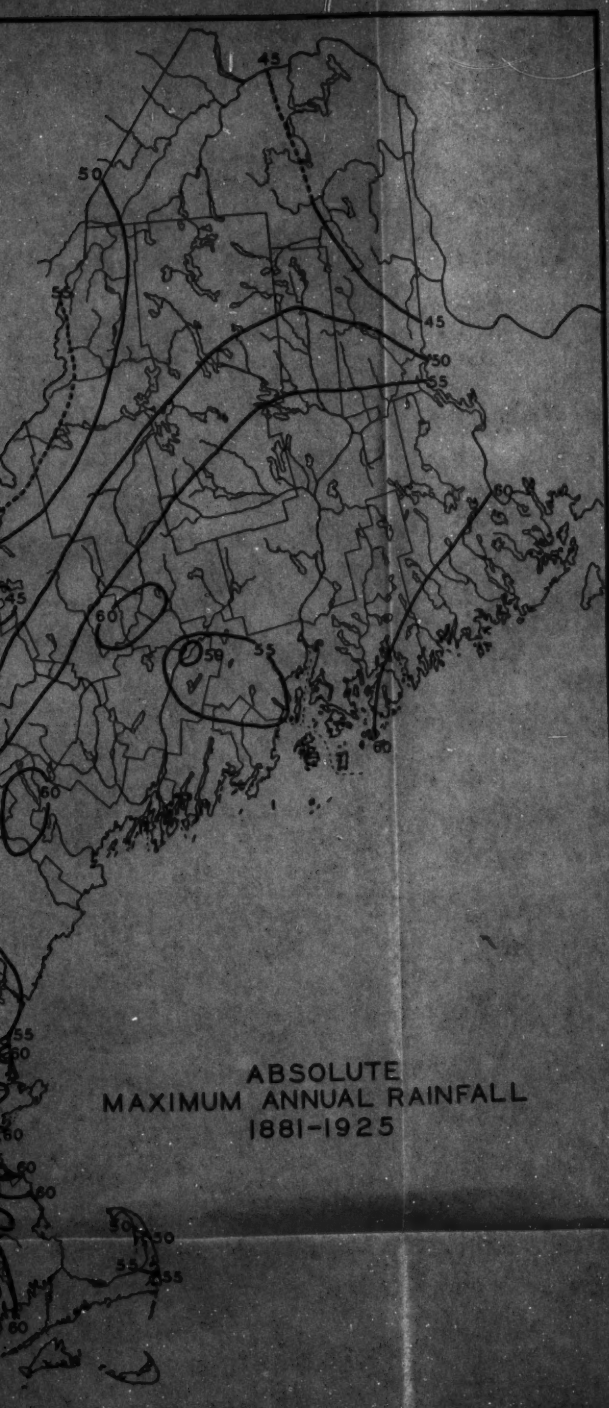

ABSOLUTE
MAXIMUM ANNUAL RAINFALL
1881-1925

ADAPTED FROM MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH'S MAP OF NEW ENGLAND - S. M. GOODNOUGH CHIEF ENGINEER
DRAWN BY G. H. BURNHAM, CARTOGRAPHER, GRADUATE SCHOOL OF GEOGRAPHY, CLARK UNIVERSITY, WORCESTER, MASS.

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Plate III.
N. E. W. W. ASSOCIATION.
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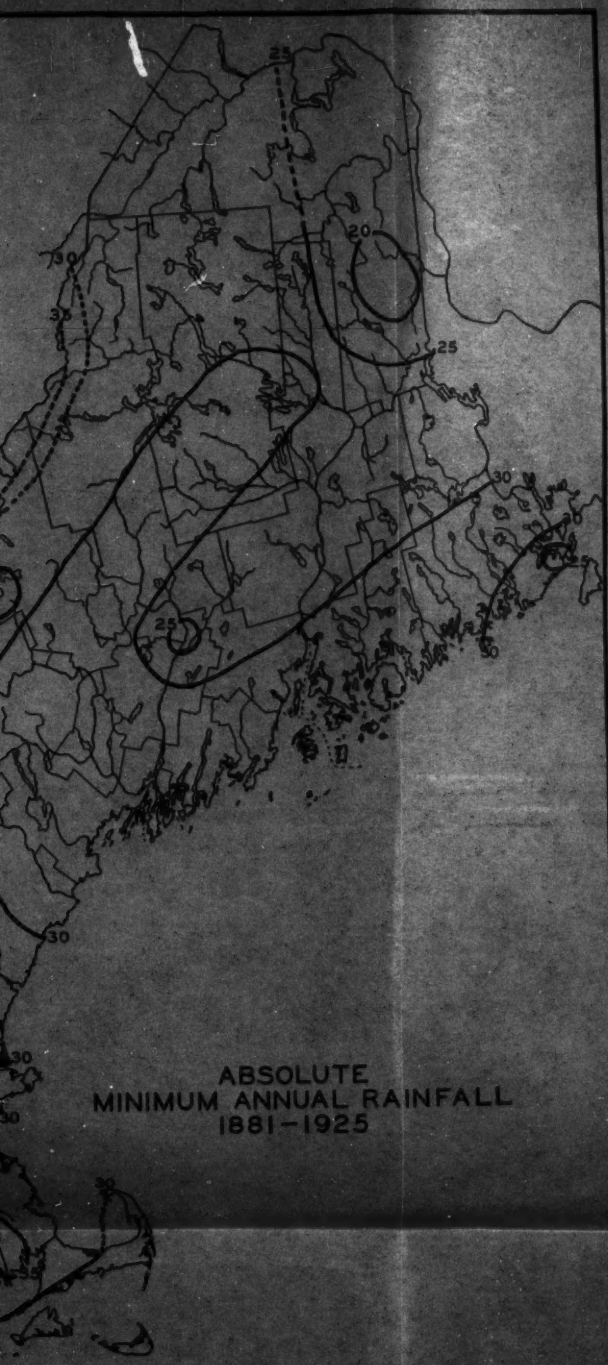
WEBER ON
RAINFALL OF
NEW ENGLAND.



ABSOLUTE
MINIMUM ANNUAL RAINFALL
1881–1925

ADAPTED FROM MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH'S MAP OF NEW ENGLAND – X. H. GOODNOUGH, CHIEF ENGINEER
DRAWN BY G. H. BURNHAM, CARTOGRAPHER, GRADUATE SCHOOL OF GEOGRAPHY, CLARK UNIVERSITY, WORCESTER MASS.

All areas of 25 in. or lower are confined to northern New England while 20 in. or lower are found only in portions of western Vermont and in northeastern Maine. The lowest annual rainfalls recorded are: — Howe's Brook, Me., 16.35 in.; Manchester, Vt., 17.68 in.; Houlton, Me., 18.75 in.; Van Buren, Me., 21.65 in.; Upper Dam, Me., 22.40 in. and Jacksonville, Vt., 22.52 in. Burlington and Cornwall, Vt., and Eastport and Fairfield, Me., all have reported an annual rainfall under 23 in.

It is interesting to note that although Provincetown and Williamstown, Mass., both have a mean annual rainfall under 40 in., the annual rainfall during this 45-year period, has never fallen to 30 in. The maximum value at Williamstown is 54 in. and at Provincetown, 48 in.; contrast this slight variability with that of Jacksonville, Vt., where the mean annual rainfall is 44.4 in., the maximum, 66.9 in. and the minimum, 22.5 in.

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THE RAINFALL OF NEW ENGLAND.

SEASONAL RAINFALL.*

BY J. HENRY WEBER.†

SEASONAL DISTRIBUTION OF RAINFALL.

The New England region has a remarkably even seasonal distribution of rainfall. (Figs. 1–4.) There are, however, considerable differences within the bounds of the New England States, particularly between the coastal rain-gaging stations and those of the interior. All stations on the southern Massachusetts coast with its adjoining islands and those on the coast of Connecticut, Rhode Island and Maine indicate a winter maximum and a summer minimum of rainfall; in the far interior the maximum comes in summer and the minimum in winter or spring. This is in accord with the seasons of maximum and minimum rainfall in marine and continental climates. Between the coast and the far interior is the region of practically uniform mean monthly rainfall, some stations having less than a ½-in. annual range. Examples of these three types are: (1) *coastal region* — Bar Harbor, Me., with means of 5.1 and 3.1 in. in March and June, respectively; (2) *far interior region* — Burlington, Vt., with means of 1.63 and 3.60 in. in February and June, respectively; (3) *intermediate region* — Waltham, Mass., highest mean, 3.76 in., in September and the least 3.33 in., in June.

In the coastal stations the months of December, January, February and March have rather uniform rainfalls, although the tendency is towards slightly higher rainfall in January and March. From April to July, the amount diminishes steadily, while in July and August there is a reaction to slightly higher rainfall, due mainly to the increasing activity of convectional storms and the added influence of West Indian hurricanes. September has a lower rainfall than either July or August and, in some cases, one as low as, or lower than, June. This is the transition period between the great activity of convectional storms and that of the extra-tropical "lows." The influence of West Indian hurricanes on the rainfall of this region in September is also less than during either the preceding or following months. Rainfall due to hurricanes was tabulated from the daily weather maps, 1904–1926, for Eastport, Portland, Boston, Block Island and Nantucket. The results indicate that this influence accounts for 4 to 5 per cent. of the annual rainfall at these stations and that the greatest proportion of this rainfall comes in August and October.

The topography of New England is shown in Fig. 5, a relief map of the New England States and adjoining regions.

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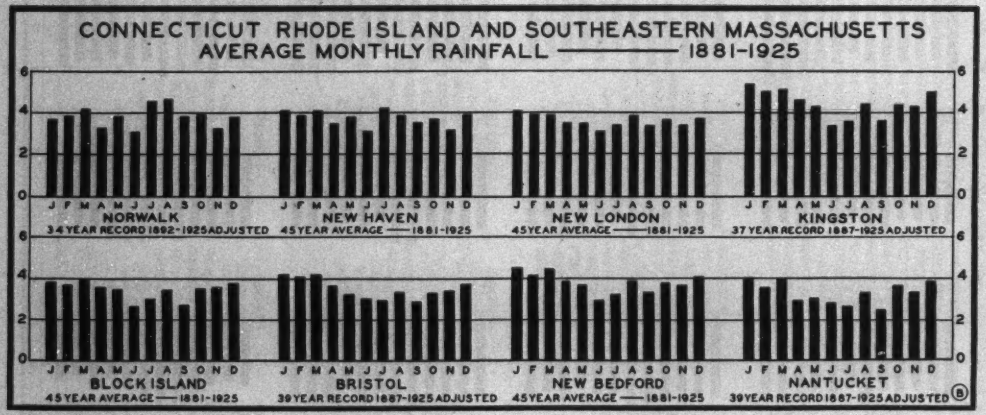
CONNECTICUT RHODE ISLAND AND SOUTHEASTERN MASSACHUSETTS
AVERAGE MONTHLY RAINFALL ——— 1881-1925
NORWALK
34 YEAR RECORD 1892-1925 ADJUSTED
NEW HAVEN
45 YEAR AVERAGE —— 1881-1925
NEW LONDON
45 YEAR AVERAGE —— 1881-1925
KINGSTON
37 YEAR RECORD 1887-1925 ADJUSTED
BLOCK ISLAND
45 YEAR AVERAGE —— 1881-1925
BRISTOL
39 YEAR RECORD 1887-1925 ADJUSTED
NEW BEDFORD
45 YEAR AVERAGE —— 1881-1925
NANTUCKET
39 YEAR RECORD 1887-1925 ADJUSTED
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Fig. 1.

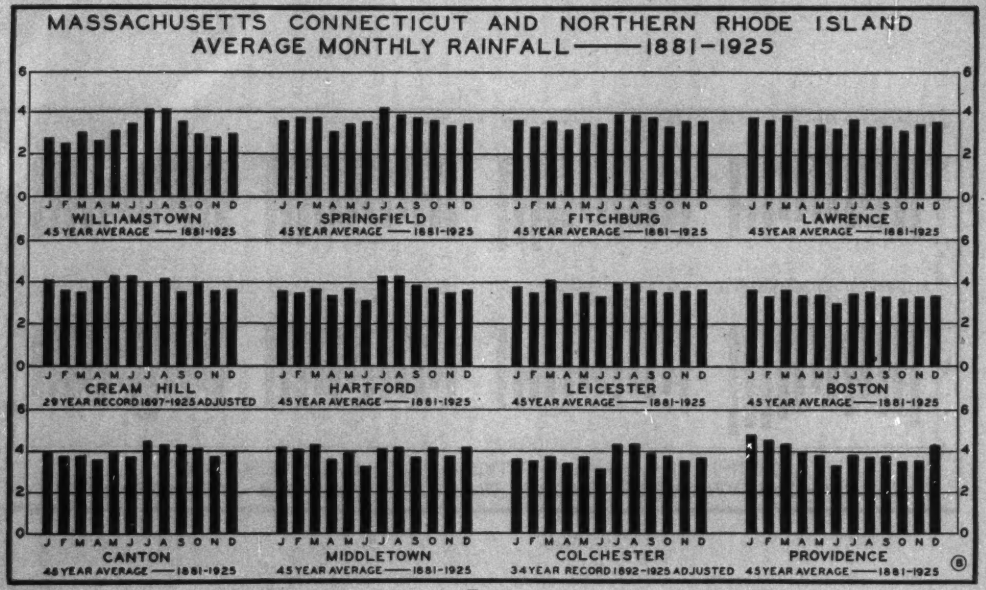

MASSACHUSETTS CONNECTICUT AND NORTHERN RHODE ISLAND
AVERAGE MONTHLY RAINFALL——1881-1925
J F M A M J J A S O N D
WILLIAMSTOWN
45 YEAR AVERAGE —— 1881-1925
SPRINGFIELD
45 YEAR AVERAGE —— 1881-1925
FITCHBURG
45 YEAR AVERAGE —— 1881-1925
LAWRENCE
45 YEAR AVERAGE —— 1881-1925
CREAM HILL
29 YEAR RECORD 1897-1925 ADJUSTED
HARTFORD
45 YEAR AVERAGE —— 1881-1925
LEICESTER
45 YEAR AVERAGE —— 1881-1925
BOSTON
45 YEAR AVERAGE —— 1881-1925
CANTON
48 YEAR AVERAGE —— 1881-1925
MIDDLETOWN
45 YEAR AVERAGE —— 1881-1925
COLCHESTER
34 YEAR RECORD 1892-1925 ADJUSTED
PROVIDENCE
45 YEAR AVERAGE —— 1881-1925
B

FIG. 2.

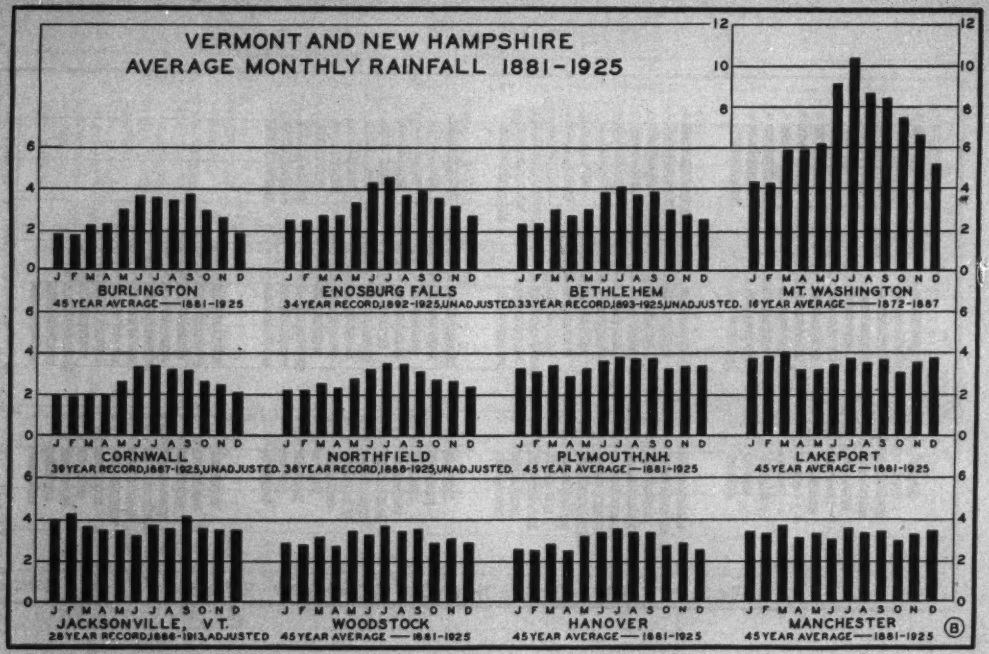

VERMONT AND NEW HAMPSHIRE
AVERAGE MONTHLY RAINFALL 1881-1925
J F M A M J J A S O N D
BURLINGTON
45 YEAR AVERAGE — 1881-1925
ENOSBURG FALLS
34 YEAR RECORD, 1892-1925, UNADJUSTED.
BETHLEHEM
33 YEAR RECORD, 1893-1925, UNADJUSTED.
MT. WASHINGTON
16 YEAR AVERAGE — 1872-1887
CORNWALL
38 YEAR RECORD, 1887-1925, UNADJUSTED.
NORTHFIELD
38 YEAR RECORD, 1888-1925, UNADJUSTED.
PLYMOUTH, N.H.
45 YEAR AVERAGE — 1881-1925
LAKEPORT
45 YEAR AVERAGE — 1881-1925
JACKSONVILLE, VT.
28 YEAR RECORD, 1886-1913, ADJUSTED
WOODSTOCK
45 YEAR AVERAGE — 1881-1925
HANOVER
45 YEAR AVERAGE — 1881-1925
MANCHESTER
45 YEAR AVERAGE — 1881-1925
(B)

FIG. 3.

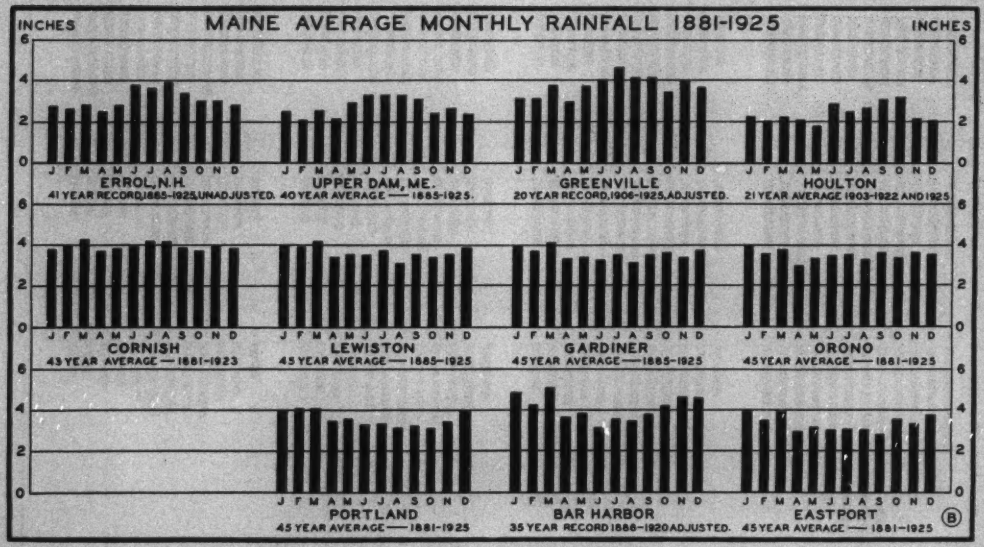
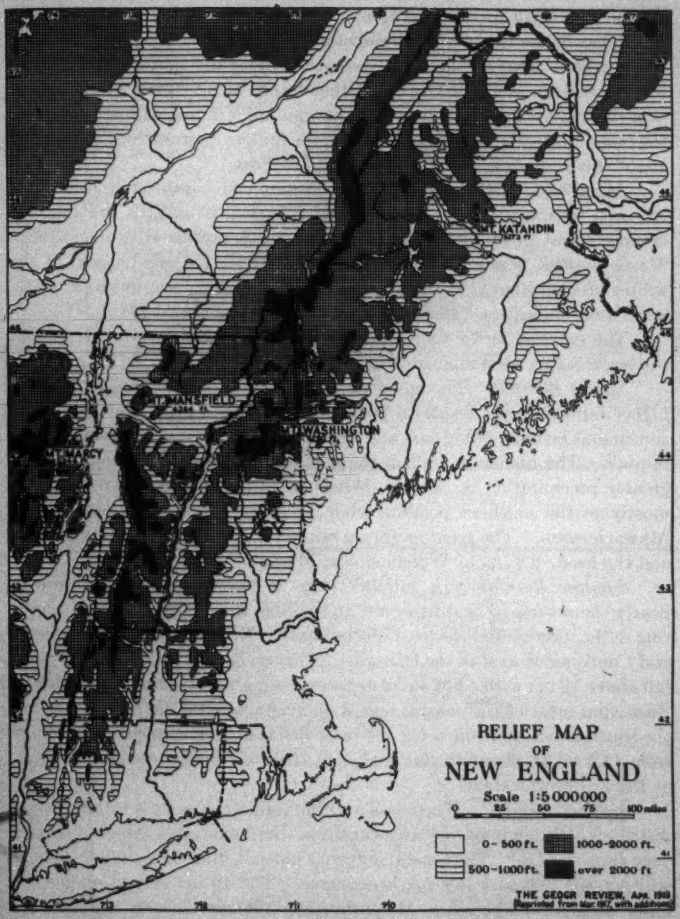

MAINE AVERAGE MONTHLY RAINFALL 1881-1925
INCHES
INCHES
J F M A M J J A S O N D
ERROL, N.H.
41 YEAR RECORD, 1885-1925, UNADJUSTED.
UPPER DAM, ME.
40 YEAR AVERAGE — 1885-1925.
GREENVILLE
20 YEAR RECORD, 1906-1925, ADJUSTED.
HOULTON
21 YEAR AVERAGE 1903-1922 AND 1925
CORNISH
43 YEAR AVERAGE — 1881-1923
LEWISTON
45 YEAR AVERAGE — 1885-1925
GARDINER
45 YEAR AVERAGE — 1885-1925
ORONO
45 YEAR AVERAGE — 1881-1925
PORTLAND
45 YEAR AVERAGE — 1881-1925
BAR HARBOR
35 YEAR RECORD 1886-1920 ADJUSTED.
EASTPORT
45 YEAR AVERAGE — 1881-1925
B

Fig. 4.



Courtesy of the Geographical Review published by the American Geographical Society of New York.

FIG. 5.

MEAN SEASONAL RAINFALL (SOUTHERN NEW ENGLAND).

Winter Rainfall. The mean winter rainfall (Fig. 6) for most of southern New England amounts to between 10 and 13 in. A belt of higher rainfall, above 12 in., extends from western Connecticut northeastward to the

Massachusetts coast, reaching a maximum in southern Rhode Island where a small area is enclosed by the 14-in. isohyet. The southern portion of this region has higher mean winter temperatures and is in closer proximity than the northern area, to the main sources of moisture, namely the Gulf of Mexico and the Atlantic Ocean. Other things being equal, we should expect the highest rainfall here. A higher rainfall is indicated just back from the coast, particularly in Rhode Island; the factors instrumental in bringing about this condition have been explained in Part I.

About one-fourth to one-third of the winter precipitation in the southern area falls as snow.* This proportion increases towards the interior, being greatest in the higher elevations of the Berkshire Hills in northern Massachusetts, where snowfall accounts for by far the greater part of the winter precipitation. In the northern portion of the area, there are many small areas indicating values below 10 in. and a few above 12 in.

The greatest mean winter rainfall is 15.0 in. at Kingston, R. I., and the least, 8.2 in. at Williamstown, Mass.

Spring Rainfall. The mean spring rainfall (Fig. 7), again indicates a higher rainfall in the southern portion of the region although there is no continuous belt extending east and west, as was the case in the mean winter rainfall. The higher rainfall in the southern region is due chiefly to the greater precipitation in March. Areas of 12 in. or greater are confined mostly to the southern portion, while 10 in. or lower are found only in Massachusetts. The greatest spring rainfall is 13.7 in., at Kingston, R. I., and the least, 8.8 in., at Williamstown, Mass.

Summer Rainfall. In summer (Fig. 8) the rainfall distribution is nearly the reverse of that in winter and spring, the greatest rainfall occurring in the interior and the least on the coast. Nearly all of Massachusetts and Connecticut west of the Connecticut River, have a mean summer rainfall above 12 in., with a few small areas exceeding 14 in. The Narragansett Basin and most of the coastal region of Massachusetts have under 10 in., the southeastern portion being the most deficient. The mean values vary from 14.5 in. at Savoy in the Berkshire Hills of Massachusetts, to 8.3 in. at Provincetown, Mass.

Autumn Rainfall. The mean autumn rainfall (Fig. 9) is rather evenly distributed throughout the area, and for the region as a whole averages very close to 11 in. The coastal influence noted during the summer months still persists but to a less marked degree. The 10-in. isohyet encloses a lesser area in southeastern Massachusetts, than it does in the summer season, although in most of northeastern Massachusetts the values are somewhat lower than during the preceding season. The lowest mean value, however, is at Williamstown, 9.2 in.

*For a complete discussion of the geographical distribution of snowfall in this area, see C. F. Brooks's study of "New England Snowfall," *Monthly Weather Review*, 1917, Vol. 45, pp. 271–285, 30 figs.

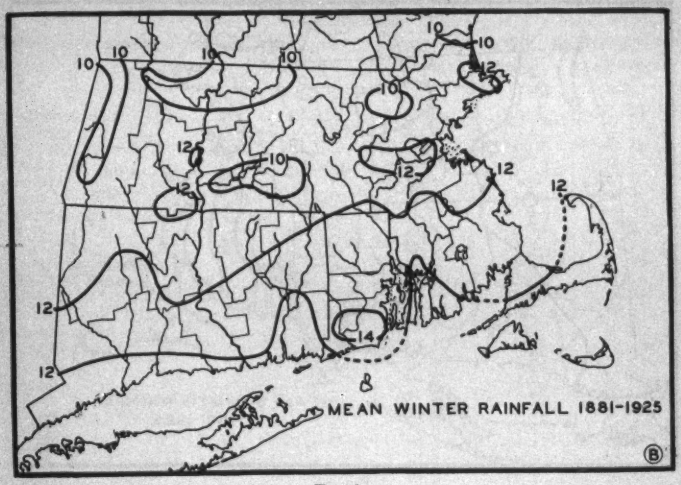

MEAN WINTER RAINFALL 1881-1925
B

FIG. 6.

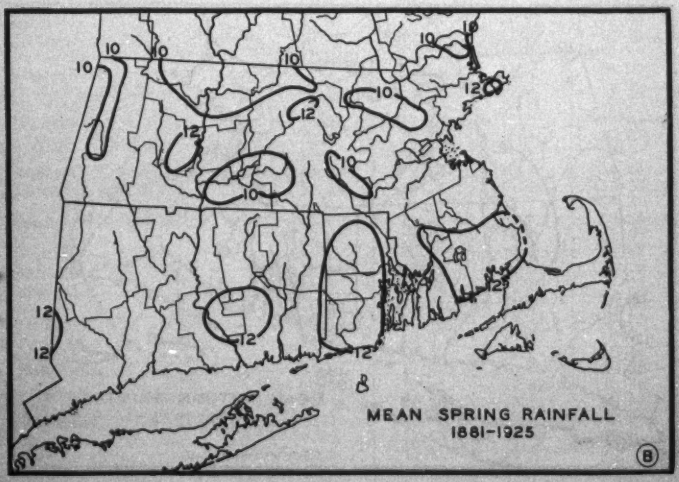

MEAN SPRING RAINFALL
1881-1925
B

FIG. 7.

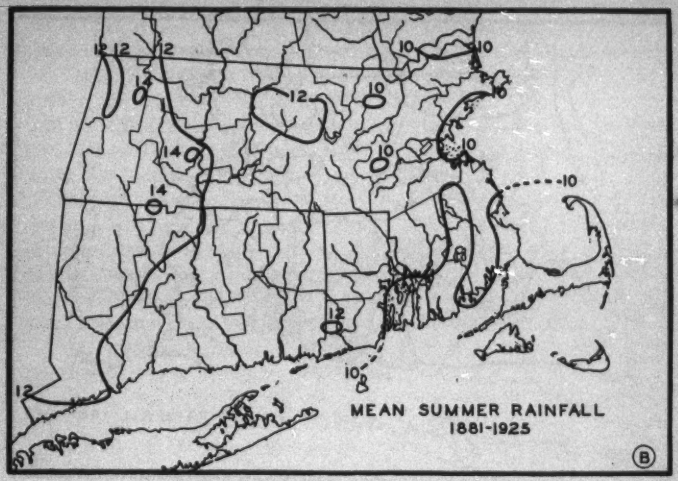

MEAN SUMMER RAINFALL
1881-1925
B

FIG. 8.

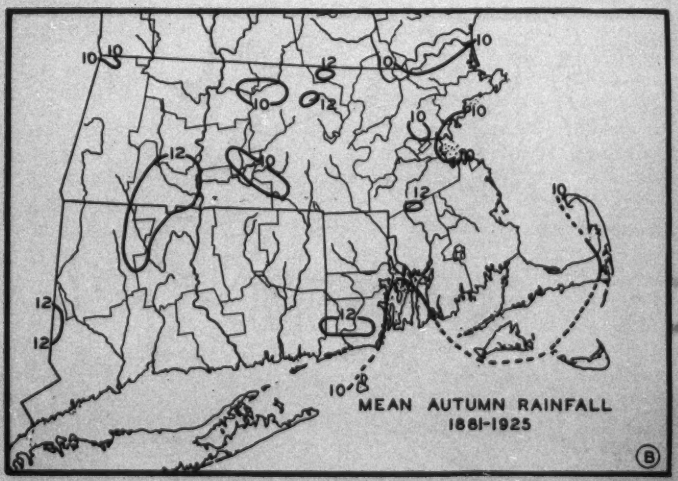

MEAN AUTUMN RAINFALL
1881-1925
B

FIG. 9.

MEAN SEASONAL RAINFALL IN SOUTHERN NEW ENGLAND.

Massachusetts.

	Winter.	Spring.	Summer.	Autumn.
Acushnet	12.89	12.27	10.05	11.52
Agawam	12.1	12.1	12.7	12.1
Amherst	10.59	10.62	11.77	10.71
Ashby	10.4	11.9	11.8	12.4
Ashland	12.15	11.02	9.87	10.40
Athol	8.7	9.1	12.6	9.9
Attleborough	12.0	11.5	10.4	10.8
Bedford	10.2	9.5	10.2	9.7
Belchertown	10.4	10.1	11.2	9.7
Blue Hill (Summit)	11.99	11.47	11.24	11.53
Blue Hill (Valley)	11.6	11.1	10.6	11.1
Boston	10.15	10.19	9.65	9.54
Boylston	11.9	11.7	11.7	11.0
Bridgewater	12.1	11.6	10.6	10.7
Brockton	10.44	10.25	9.81	10.23
Cambridge	11.12	10.68	9.77	10.11
Chester	11.3	10.3	12.0	11.0
Chestnut Hill	12.29	11.34	10.66	10.96
Clinton	11.22	10.35	10.81	10.38
Colrain	10.5	11.0	11.7	11.1
Concord	10.3	10.1	10.4	10.1
Cotuit	11.1	10.7	9.2	11.1
Dalton	10.1	10.3	12.1	10.4
Danvers	10.1	11.2	9.8	10.5
Dudley	11.1	10.7	10.8	10.3
Easthampton	12.0	13.0	14.3	13.7
Egremont	10.0	10.2	12.6	10.5
Fall River	12.35	11.75	10.12	11.00
Fitchburg	10.34	10.05	11.07	10.42
Framingham	11.99	11.03	10.23	10.58
Gardner	11.4	11.5	11.7	10.9
Gloucester	12.7	12.4	10.7	11.3
Granville (a)	11.0	11.1	13.2	12.1
Granville (b)	13.5	13.0	12.8	13.3
Groton	10.4	10.6	10.4	10.6
Haverhill	10.4	10.4	9.8	9.9
Hingham	11.80	11.02	10.84	11.36
Holden	11.12	11.14	11.46	11.28
Holyoke	11.4	11.7	12.7	11.3
Hyannis	11.9	11.65	9.7	10.25
Ipswich	12.35	12.15	10.4	11.0
Lakeville	12.41	12.02	10.02	10.87
Lawrence	10.80	10.53	10.18	9.79
Leeds	11.94	12.00	12.41	11.30
Leicester	10.74	11.04	11.20	10.65
Leominster	10.56	10.64	11.42	10.75
Lincoln	8.9	9.9	10.3	9.9
Littleton	8.5	9.1	9.8	10.1
Lowell	11.64	11.17	10.58	10.39
Ludlow	9.70	10.04	11.62	10.08
Lynn	10.56	10.39	10.14	9.94
Manchester	11.1	11.0	9.7	10.8
Mansfield	13.2	11.65	11.75	12.0
Marlborough	10.3	10.2	10.3	10.7
Medford	10.9	10.6	10.2	10.2
Middleboro	12.3	11.1	9.9	10.6
Milford	10.6	10.0	10.2	10.3
Monroe Bridge	10.3	10.6	13.1	11.0

MEAN SEASONAL RAINFALL IN SOUTHERN NEW ENGLAND.

Massachusetts (Continued).

	Winter.	Spring.	Summer.	Autumn.
Monson	10.8	10.1	11.4	10.7
Nantucket	11.55	10.09	9.00	9.67
Natick	11.88	10.74	10.18	10.56
New Bedford	12.72	12.11	10.34	10.86
Newburyport	9.0	9.6	9.45	9.95
Newton	11.1	10.9	10.3	9.8
Norfolk	11.0	10.2	11.1	11.4
North Adams	10.2	10.0	12.7	10.5
North Andover	10.0	10.3	10.5	10.0
North Billerica	10.0	10.3	10.8	10.1
Northbridge	11.63	11.18	11.12	10.92
Norwood	10.2	10.3	11.6	10.5
Otis	10.3	10.7	13.3	11.2
Peabody	11.3	10.8	11.0	11.0
Pembroke	11.8	11.8	10.4	10.4
Peru	10.8	11.0	13.1	11.0
Petersham	10.5	9.75	13.3	11.45
Pittsfield	10.1	9.7	11.9	10.1
Plymouth	12.90	12.08	9.88	11.11
Prescott	10.4	11.0	12.7	11.1
Princeton	11.11	10.95	12.22	10.82
Provincetown	10.85	10.32	8.32	9.45
Quincy	10.9	10.2	11.3	10.8
Reading	11.0	10.8	10.5	10.5
Rochester	12.95	12.60	11.1	11.65
Rockport	11.4	10.8	10.3	10.6
Rowe	10.0	9.5	11.9	11.5
Rutland	10.1	11.0	12.3	10.9
Salem	10.6	10.6	9.8	10.1
Savoy	11.5	10.2	14.5	11.1
Sharon	12.1	10.8	10.8	10.4
Shelburne Falls	8.8	9.6	11.3	10.5
Somerset	11.87	11.74	10.07	10.65
Somerville	10.7	10.8	10.2	10.6
Southampton	11.4	12.0	12.7	12.2
Southboro	12.70	11.56	10.66	11.17
Southbridge	10.9	11.5	10.4	11.1
Springfield	10.42	9.94	11.60	10.55
Sterling	11.0	10.4	11.1	10.5
Stoneham	11.5	11.1	11.8	11.2
Taunton	13.21	12.20	10.78	11.48
Templeton	10.05	9.55	10.5	9.7
Turners Falls	9.5	9.8	10.4	10.8
Vineyard Haven	11.8	11.0	8.9	10.6
Walpole	10.8	10.3	10.5	10.1
Waltham	10.72	10.57	10.65	10.74
Wareham	12.5	12.5	10.0	10.5
Warren	9.4	9.8	11.5	9.9
Webster	11.19	10.79	10.67	10.19
Wellesley	11.7	11.4	10.9	10.8
Wenham	10.14	10.34	10.92	10.75
Westborough	11.30	10.96	10.83	10.88
West Brookfield	9.3	9.7	11.8	10.2
Westfield	12.7	11.5	13.0	12.3
West Granville	11.1	11.9	13.5	12.0
Westminster	12.2	12.6	12.1	12.5
Weston	11.4	10.9	10.6	10.5
Williamsburg	9.9	10.6	11.4	11.7

MEAN SEASONAL RAINFALL IN SOUTHERN NEW ENGLAND.

Massachusetts (Continued).

	Winter.	Spring.	Summer.	Autumn.
Williamstown	8.21	8.75	11.67	9.20
Winchendon	10.0	10.0	11.7	10.7
Winchester	10.6	9.6	9.9	9.9
Woods Hole	11.35	10.7	8.9	10.05
Worcester	10.16	10.04	10.31	10.37
Worthington	11.6	11.3	12.5	11.4

MEAN SEASONAL RAINFALL IN SOUTHERN NEW ENGLAND.

Connecticut.

	Winter.	Spring.	Summer.	Autumn.
Bridgeport	11.79	11.78	12.51	11.30
Burlington (a)	10.3	11.2	13.1	11.8
Burlington (b)	12.5	12.8	12.8	13.0
Canton	11.66	11.31	12.39	11.93
Colchester	13.3	12.8	11.7	11.7
Cream Hill	11.3	11.8	12.5	11.0
Danielson	12.3	10.6	10.8	11.3
Enfield	10.3	10.6	12.2	11.6
Fall Village	10.27	10.24	12.28	11.00
Greenwich	10.84	10.63	11.74	10.42
Hartford	10.66	10.55	11.65	11.04
Hartland	13.0	11.8	14.0	12.8
Lake Konomoc	12.7	12.0	10.3	10.9
Mansfield	11.3	10.9	11.5	10.5
Middletown	12.19	11.66	11.38	11.40
Nepaug	11.9	11.6	12.4	12.2
New Haven	11.83	11.29	11.30	10.45
New London	11.74	10.98	10.42	10.44
Newtown	12.0	11.8	11.9	11.4
No. Grosvenor Dale	11.9	11.2	10.9	10.4
Norwalk	11.35	11.32	12.73	11.08
Norwich	11.19	10.80	10.53	10.12
Simsbury	11.1	10.45	11.35	11.1
Southington	11.26	10.56	10.97	10.46
Voluntown	12.85	11.55	10.83	11.09
Wallingford	13.35	11.68	11.29	10.98
Waterbury	12.60	11.46	12.34	10.87

MEAN SEASONAL RAINFALL IN SOUTHERN NEW ENGLAND.

Rhode Island.

	Winter.	Spring.	Summer.	Autumn.
Block Island	11.29	11.00	9.13	9.79
Bristol	11.98	10.99	9.31	9.60
Cranston	13.65	12.25	10.3	11.3
Foster	12.9	12.5	11.3	11.7
Hope	13.35	12.30	11.05	11.62
Hopkinton	13.8	12.6	12.1	12.3
Kingston	15.04	13.70	11.25	12.15
Lonsdale	12.3	11.5	11.0	10.9
Narragansett Pier	12.56	12.47	10.29	10.91
Pawtucket	13.08	11.52	10.95	10.49
Providence	13.43	11.91	10.62	11.00
Scituate	12.4	11.8	11.1	10.9
South Scituate	12.75	12.1	11.8	11.35
Wallum Pond	11.1	10.7	11.7	11.2
Woonsocket	12.59	11.90	11.34	11.22

THE RAINFALL OF NEW ENGLAND.

Mean Monthly Rainfall of Southern New England.*

BY J. HENRY WEBER.†

The mean January rainfall (Fig. 1) is greatest in the southern portion, exceeding 5 in. in southern Rhode Island. The 4-in. isohyet encloses nearly all of Massachusetts south of a line from the vicinity of Boston to the east of Worcester, all of Rhode Island and the greater portion of Connecticut, exclusive of the north central portion. The southwestern coast of Connecticut and portions of Cape Cod have under 4 in. Williamstown, in the Hoosic Valley, and Shelburne Falls, in the Deerfield Valley, are the only areas having under 3 in. Kingston, R. I., with 5.21 in., has the highest mean value; this is also the highest mean monthly rainfall reported by any of the longer record stations in southern New England.

In February (Fig. 2) the general rainfall distribution is similar to that of January, although the area enclosed by the 4-in. isohyet is less. Along the entire Connecticut coast the rainfall is under 4 in., whereas in January only the southwestern portion experienced that condition. The 5-in. isohyet has disappeared from southern Rhode Island, although Kingston has 4.94 in. Given the same number of days as January, the 5-in. isohyet would appear here, as it did in January. Cape Cod and part of the Narragansett Basin, have under 4 in.

Williamstown, with a mean of 2.52 in., has the lowest February rainfall in the area; this is also the lowest mean monthly rainfall in southern New England.

The March mean rainfall (Fig. 3) is practically a duplicate of that of January, there being no differences worthy of note. December, January, February and March, are the months of greatest excess in the semi-marine conditions on the southern coast and the continental type in the interior.

April is the month of minimum mean rainfall (Fig. 4) for most of the northern portion; here the greater proportion of the stations have values between 3.0 and 3.5 in., while northwestern Massachusetts is the only area of any extent with amounts below 3 in. Nearly all of Rhode Island and smaller areas to the east and west have over 4 in. In April the snow cover to the north and the cold water bodies to the eastward favor the development and maintenance of a high pressure area over the northeast. This factor plus the decreasing activity of extra-tropical lows is instrumental in producing drier conditions than in the previous month, throughout the entire area.

*Editor's Note: Previously printed in this Journal, Vol. XLII, No. 3, September, 1928, pp. 291–302.
†Clark University, Worcester, Mass.

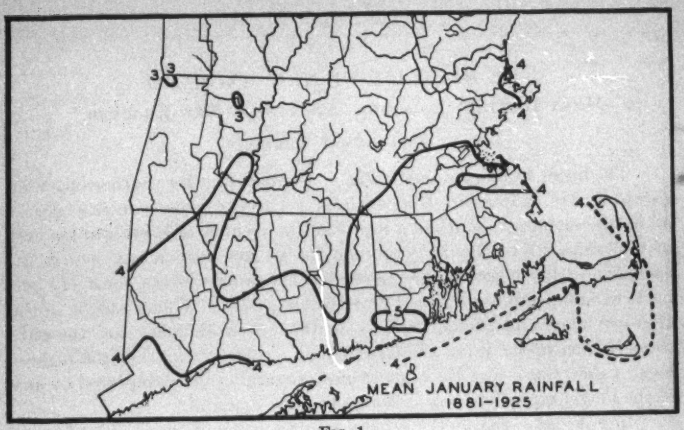

MEAN JANUARY RAINFALL
1881-1925

FIG. 1.

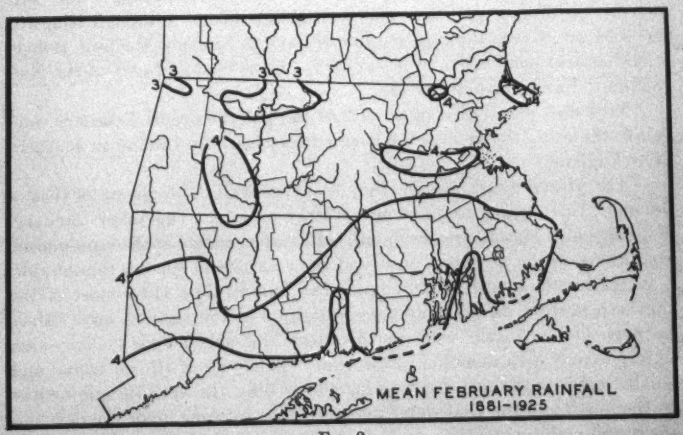

MEAN FEBRUARY RAINFALL
1881-1925

FIG. 2.

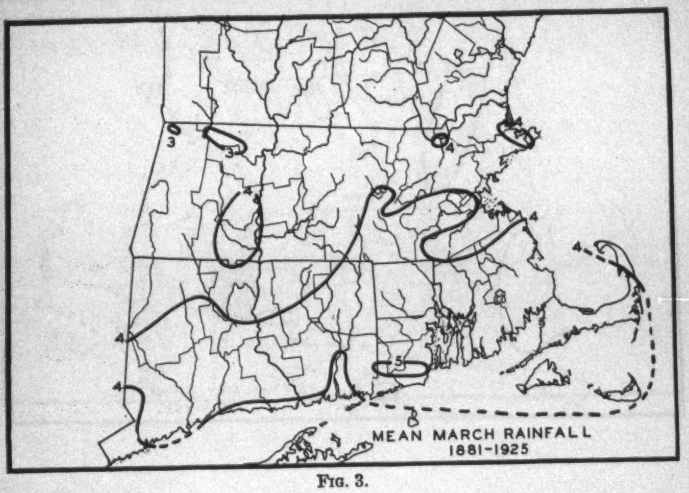

MEAN MARCH RAINFALL
1881-1925

FIG. 3.

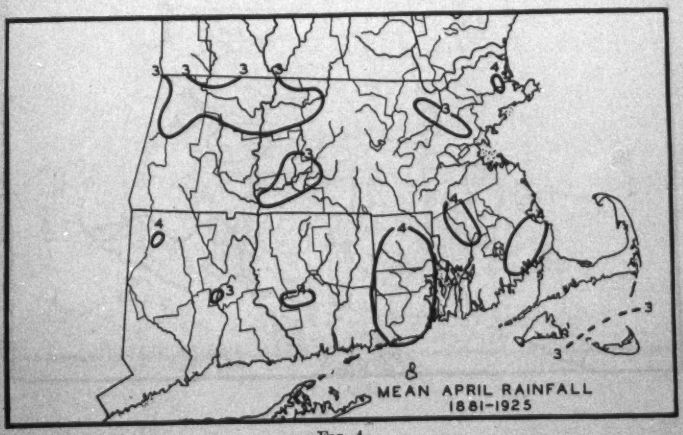

MEAN APRIL RAINFALL
1881-1925

FIG. 4.

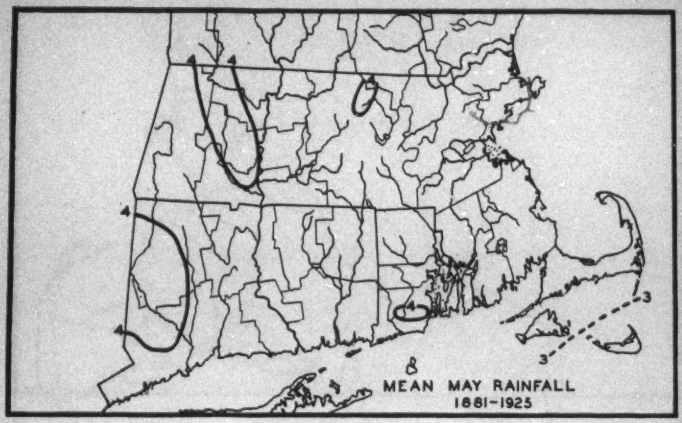


FIG. 5.

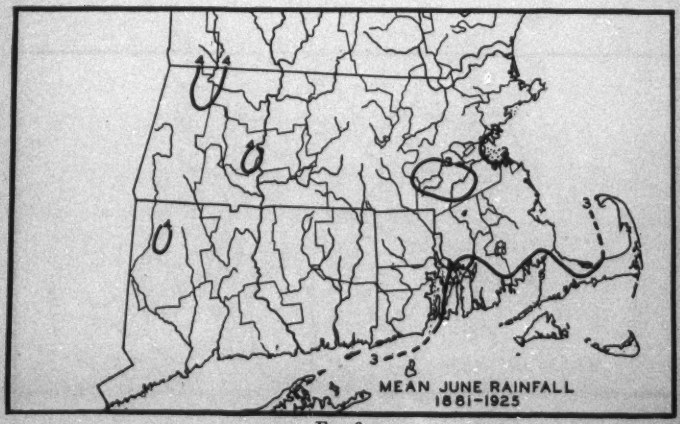


FIG. 6.

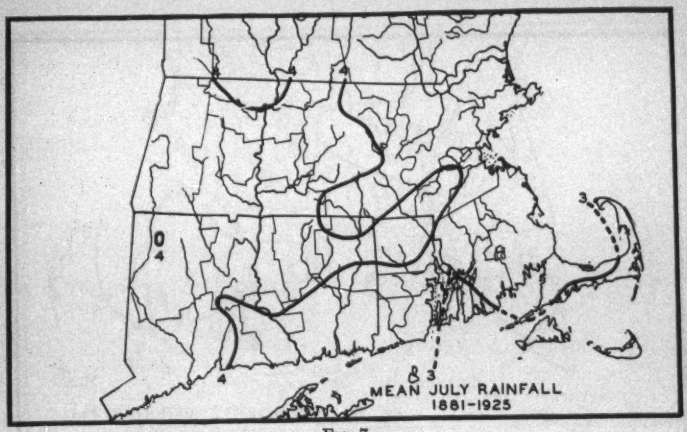

MEAN JULY RAINFALL
1881–1925

FIG. 7.

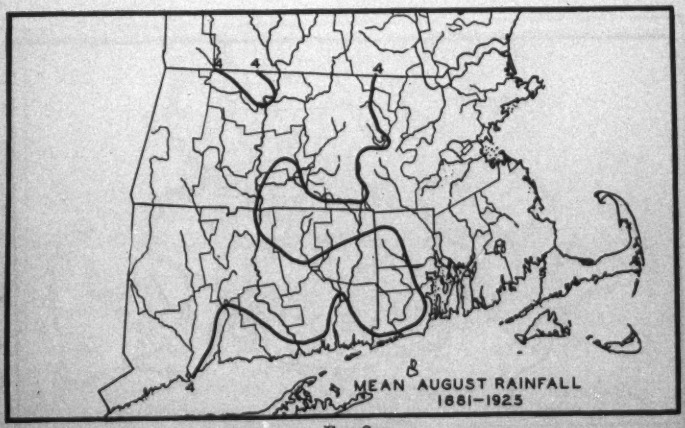

MEAN AUGUST RAINFALL
1881–1925

FIG. 8.

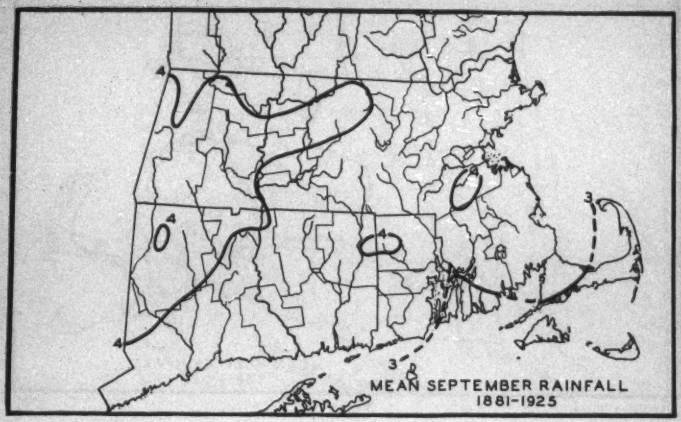

MEAN SEPTEMBER RAINFALL
1881-1925

FIG. 9.

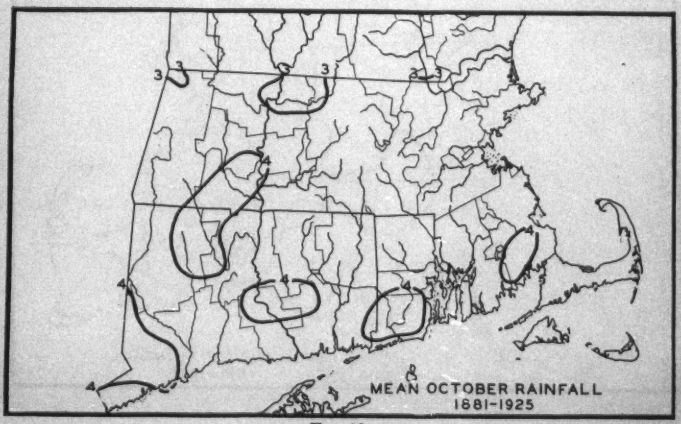

MEAN OCTOBER RAINFALL
1881-1925

FIG. 10.

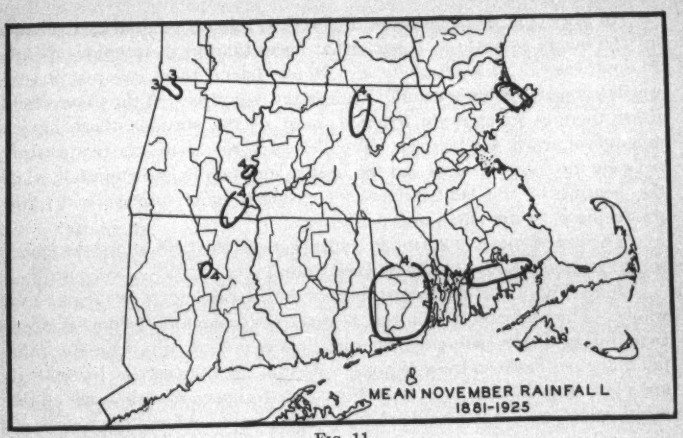
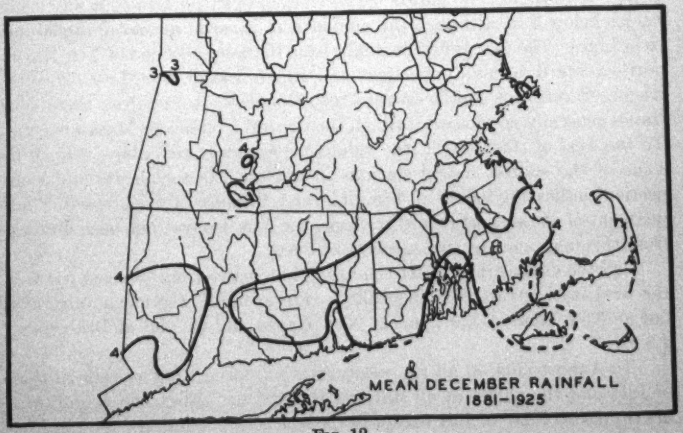

3
3
4
4
8
MEAN NOVEMBER RAINFALL
1881-1925

FIG. 11.


3
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8
MEAN DECEMBER RAINFALL
1881-1925

FIG. 12.

Kingston, with 4.5 in., has the highest mean and Williamstown, with 2.6 in., has the lowest.

In May (Fig. 5) the mean rainfall is even less varied than in April and, for the region as a whole, is somewhat lower than in the previous month. In southeastern Massachusetts and Rhode Island there is a reaction towards a somewhat lower rainfall while in the region west of the Connecticut River there is an opposite reaction, most of the stations there having amounts of nearly 4 in. or over. The increasing contrast in the temperature between the coastal waters and the heated land favors lower rainfall, while the heating of the land induces increasing thunderstorm activity, thus producing a reverse effect in the interior.

The lowest mean is 2.9 in. at Nantucket and the highest, for the longer record stations, 4.3 in. at Cream Hill, Conn.

June (Fig. 6) has the lowest mean monthly rainfall for the region as a whole. The temperature contrast between the ocean and the land is larger than during the preceding month and there is, accordingly, a greater rainfall difference between these regions. West of the Connecticut River there are a few areas having more than 4 in. while to the eastward nearly all the mean values are in the neighborhood of 3 in., Cape Cod and the islands off the southern coast having the lowest mean values. Provincetown reports the lowest mean, 2.57 in.

In July (Fig. 7) the greater rainfall in the interior and the lower on the coasts, is most clearly shown. The southeastern portion still has mean values below 3 in. although the amounts, in general, are not quite so low as in June. The 4-in. isohyet extends from the neighborhood of New Haven northeastward across Connecticut and Rhode Island into Massachusetts, whence it recurves southwestward into Connecticut and from there continues generally northward through the Central Uplands of Massachusetts. To the west of this isohyet, the values are generally well above 4 in. with some of the shorter record stations in western Massachusetts and Connecticut indicating values of 5 in. or over. Because of unsatisfactory adjustment of these short record stations, the 5-in. isohyet has been omitted from this map and the two subsequent ones.

On the Connecticut coast the rainfall increases from the east towards the west, with greater continentality. For example, the mean July rainfall at New London is 3.4 in., at New Haven, 4.2 in. and at Bridgeport, 4.8 in.

In August (Fig. 8) all the coastal stations have a higher rainfall than in July and the values at all stations exceed 3 in. Elsewhere conditions are similar to those of July except in the southern portion, the 4-in. isohyet pushes eastward nearly to Narragansett Bay, while along the Massachusetts-Connecticut boundary there is a westward bend of this line to the Connecticut Valley. From New Haven eastward along the coast, the rainfall is under 4 in., these values being less than is indicated a short distance inland.

On the September mean rainfall map (Fig. 9) the 3-in. isohyet is again shown on the southeastern coast, while the 4-in. line has retreated to western Massachusetts and Connecticut. The lowest mean value is 2.55 in. at Nantucket, and the highest for the longer record stations, 4.4 in. at Falls Village, Conn.

October (Fig. 10) shows a decided marine type increase in the southern and southeastern portions while there is a marked continental type of decrease in the northern and western portions. Areas of 4 in. or over are confined to the southern and southwestern parts. In northern Massachusetts the average is about 3 in., a few stations having values slightly below that figure.

In November (Fig. 11) the rainfall in the northern portion is somewhat higher than in October, while there is little difference in the southern part. In western Connecticut however, there is a slight decrease. Southern and central Rhode Island are enclosed by the 4-in. isohyet, these being the only areas of any extent reporting values above 4 in. Williamstown is the only station to have a mean rainfall below 3 in.

In December (Fig. 12) the conditions are similar to those of January, February, and March, the higher rainfall being in the southern portion and the least in the northern. Kingston with 4.9 in., has the highest mean rainfall while Williamstown, as in the case of the mean November rainfall, is the only station having under 3 in.

Mean Monthly Rainfall of Southern New England.

Massachusetts.

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Acushnet	4.30	4.22	4.52	3.87	3.88	3.03	3.23	3.79	3.39	4.07	4.06	4.37
Agawam	3.5	4.3	4.0	3.7	4.4	3.9	4.5	4.3	4.4	3.9	3.8	4.3
Amherst	3.58	3.44	3.81	3.13	3.49	4.18	4.18	4.10	4.02	3.33	3.36	3.57
Ashby	3.5	3.3	3.6	4.1	4.2	3.7	3.7	4.4	3.6	4.1	4.7	3.6
Ashland	4.09	4.18	4.23	3.55	3.24	3.05	3.43	3.39	3.54	3.32	3.54	3.88
Attleborough	4.3	4.1	4.2	3.8	3.5	3.1	3.7	3.6	3.8	3.2	3.8	3.6
Bedford	3.5	3.4	3.45	3.0	3.1	3.2	3.6	3.4	3.4	3.15	3.1	3.3
Belchertown	3.7	3.5	3.7	3.0	3.4	3.6	3.8	3.8	3.4	3.0	3.3	3.2
Blue Hill (Summit)	4.19	3.90	4.19	3.70	3.58	3.41	4.00	3.83	4.01	3.80	3.72	3.90
Blue Hill (Valley)	4.1	3.7	4.1	3.5	3.5	3.1	3.9	3.6	3.7	3.7	3.7	3.8
Boston	3.59	3.38	3.57	3.30	3.32	2.93	3.31	3.41	3.23	3.11	3.20	3.28
Boylston	4.0	4.0	4.3	3.9	3.5	3.7	4.0	4.0	3.8	3.4	3.8	3.9
Bridgewater	4.3	4.0	4.35	3.7	3.5	3.1	3.7	3.8	3.55	3.6	3.6	3.8
Brockton	3.67	3.37	3.75	3.16	3.34	3.06	3.37	3.38	3.49	3.33	3.41	3.40
Cambridge	3.91	3.73	3.86	3.55	3.27	3.08	3.35	3.34	3.46	3.17	3.48	3.48
Chester	3.8	4.0	3.6	3.4	3.3	3.2	4.7	4.1	3.8	3.3	3.9	3.5
Chestnut Hill	4.25	4.21	4.07	3.77	3.50	3.38	3.60	3.68	3.75	3.55	3.66	3.83
Clinton	3.76	3.72	3.95	3.17	3.23	3.33	3.72	3.76	3.48	3.33	3.57	3.74
Colrain	3.4	3.3	3.5	4.0	3.9	4.0	4.0	3.8	3.6	3.5	3.9	3.8
Concord	3.5	3.4	3.5	3.2	3.4	3.3	3.7	3.4	3.5	3.2	3.4	3.4
Cotuit	3.6	3.6	3.8	3.6	3.3	2.6	2.8	3.8	3.6	4.0	3.5	3.9
Dalton	3.5	3.4	3.8	3.1	3.4	3.4	4.7	4.0	4.1	3.0	3.3	3.2
Dudley	3.6	3.6	4.1	3.2	3.4	3.3	3.7	3.8	3.6	3.3	3.4	3.8
Easthampton	4.0	3.9	4.7	4.1	4.2	4.9	4.4	5.0	5.0	4.6	4.1	4.1
Egremont	3.2	3.3	3.2	3.4	3.6	3.8	4.5	4.3	4.1	3.2	3.2	3.5
Fall River	4.44	3.97	4.35	3.83	3.57	2.98	3.35	3.79	3.21	3.84	3.95	3.94
Fitchburg	3.57	3.28	3.49	3.14	3.42	3.40	3.86	3.81	3.66	3.27	3.49	3.49
Framingham	4.10	4.02	4.14	3.53	3.36	3.23	3.50	3.55	3.49	3.43	3.66	3.87
Gardner	3.9	3.7	3.9	4.1	3.5	3.5	3.9	4.3	3.5	3.5	3.9	3.8
Gloucester	4.3	4.3	4.9	3.7	3.8	3.6	3.6	3.5	3.4	3.9	4.0	4.1
Granville (a)	3.75	3.75	3.75	3.5	3.85	3.4	4.7	5.1	4.2	4.2	3.7	3.5
Granville (b)	4.3	4.7	4.9	4.2	3.9	3.6	4.7	4.5	4.6	3.9	4.8	4.5
Groton	3.5	3.5	3.7	3.5	3.4	3.4	3.3	3.7	3.7	3.4	3.5	3.4
Haverhill	3.5	3.5	3.8	3.3	3.3	3.3	3.5	3.0	3.3	3.4	3.2	3.4
Hingham	4.05	4.83	3.89	3.63	3.50	3.22	3.87	3.75	3.67	3.91	3.78	3.92
Holden	3.72	3.66	4.12	3.44	3.58	3.45	4.20	3.81	3.85	3.65	3.78	3.74
Holyoke	3.7	3.8	4.2	3.5	4.0	3.8	4.7	4.2	3.8	4.0	3.5	3.9
Hyannis	4.2	3.8	4.5	3.55	3.6	3.1	3.1	3.5	2.9	3.55	3.8	3.9
Ipswich	4.35	4.3	4.25	4.3	3.6	3.9	3.3	3.2	3.3	3.7	4.0	3.7
Lakeville	4.41	4.01	4.50	3.75	3.77	3.18	3.33	3.51	3.34	3.77	3.76	3.99
Lawrence	3.71	3.56	3.86	3.31	3.36	3.19	3.70	3.29	3.27	3.11	3.41	3.53
Leeds	3.97	4.08	4.23	3.57	4.20	3.70	4.18	4.53	4.00	3.68	3.62	3.89
Leicester	3.68	3.45	4.11	3.44	3.49	3.27	3.97	3.96	3.59	3.48	3.58	3.61
Leominster	3.53	3.47	3.68	3.30	3.66	3.46	4.01	3.95	3.77	3.41	3.57	3.56
Lincoln	2.9	3.1	3.2	3.1	3.6	3.2	3.9	3.2	3.4	3.4	3.1	2.9
Littleton	2.95	2.65	3.0	3.0	3.1	2.8	3.3	3.7	3.5	3.35	3.25	3.0
Lowell	3.89	4.03	4.03	3.64	3.50	3.35	3.62	3.61	3.56	3.21	3.62	3.72
Ludlow	3.25	3.07	3.58	3.09	3.37	3.38	4.36	3.88	3.60	3.36	3.21	3.38
Lynn	3.67	3.48	3.66	3.37	3.36	3.27	3.26	3.61	3.33	3.33	3.28	3.41
Manchester	3.8	3.8	3.7	3.7	3.6	3.0	3.3	3.4	3.6	3.5	3.7	3.5
Mansfield	4.8	4.05	3.9	4.15	3.6	3.7	4.15	3.9	4.3	3.85	3.85	4.35
Marlborough	3.5	3.5	3.5	3.2	3.5	3.2	3.7	3.4	3.5	3.5	3.7	3.3
Middleboro	4.4	4.1	4.2	3.6	3.3	3.1	3.4	3.4	3.3	3.8	3.5	3.8
Monroe Bridge	3.4	3.3	3.6	3.0	4.0	4.2	4.3	4.5	3.5	3.9	3.6	3.6
Monson	3.4	3.7	3.6	3.0	3.5	3.3	4.1	4.0	3.8	3.4	3.5	3.7
Nantucket	4.03	3.60	4.00	3.00	3.09	2.90	2.74	3.36	2.58	3.70	3.39	3.92
Natick	4.07	4.02	4.02	3.49	3.23	3.25	3.49	3.44	3.62	3.40	3.54	3.78
New Bedford	4.47	4.15	4.45	4.90	3.76	3.05	3.35	3.94	3.34	3.80	3.72	4.10

MEAN MONTHLY RAINFALL OF SOUTHERN NEW ENGLAND.
Massachusetts (Continued).

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Newburyport	3.0	3.0	3.1	3.2	3.3	3.1	3.35	3.0	2.95	3.6	3.4	3.0
Newton	4.0	3.6	3.9	3.7	3.3	3.4	3.3	3.6	3.6	3.0	3.2	3.5
Norfolk	4.0	3.4	3.5	3.3	3.4	3.0	4.1	4.0	4.0	3.9	3.5	3.6
North Adams	3.6	3.0	3.6	3.1	3.3	3.9	4.3	4.5	3.7	3.5	3.3	3.6
North Billerica	3.4	3.4	3.6	3.4	3.3	3.5	3.8	3.5	3.2	3.3	3.6	3.3
Northbridge	4.07	3.80	4.18	3.48	3.52	3.33	3.81	3.98	3.59	3.65	3.68	3.76
Norwood	3.6	3.2	3.45	3.45	3.4	3.85	4.4	4.35	4.0	3.5	3.0	3.4
Otis	3.5	3.8	3.8	3.5	3.4	3.5	5.3	3.5	4.0	3.5	3.7	3.0
Peabody	3.9	3.8	3.6	3.3	3.9	3.5	3.5	4.0	3.3	3.7	4.0	3.6
Pembroke	4.1	3.7	4.5	3.8	3.5	3.2	3.6	3.6	3.0	3.5	3.9	4.0
Peru	3.6	3.8	4.1	3.4	3.5	3.8	4.8	4.5	4.5	2.9	3.6	3.4
Petersham	3.8	3.1	3.45	3.1	3.2	3.5	4.4	5.4	3.95	3.7	3.8	3.6
Pittsfield	3.3	3.4	3.6	2.9	3.2	3.5	4.3	4.1	4.0	3.05	3.05	3.4
Plymouth	4.55	4.26	4.44	4.16	3.48	3.12	3.25	3.51	3.14	3.98	3.99	4.09
Prescott	3.3	3.5	4.1	3.7	3.2	4.1	4.3	4.3	4.1	3.5	3.5	3.6
Princeton	3.98	3.49	3.90	3.58	3.47	3.53	4.34	4.35	3.61	3.46	3.75	3.64
Provincetown	3.92	3.35	3.66	3.45	3.21	2.57	2.69	3.06	2.91	3.48	3.06	3.58
Quincy	3.8	3.7	3.7	3.4	3.1	3.4	3.9	4.0	3.6	3.6	3.6	3.4
Reading	3.9	3.8	3.8	3.9	3.1	3.4	3.6	3.5	3.3	3.4	3.8	3.3
Rochester	4.6	4.3	4.5	4.2	3.9	3.6	3.7	3.8	3.4	4.15	4.1	4.05
Rockport	4.0	3.5	3.8	3.7	3.3	3.1	3.8	3.4	3.4	3.5	3.7	3.9
Rowe	3.4	3.1	3.0	3.0	3.7	3.8	3.9	4.2	4.3	3.9	3.3	3.5
Rutland	3.5	3.3	3.8	3.5	3.7	3.6	4.3	4.4	3.7	3.7	3.5	3.3
Salem	3.6	3.5	3.5	3.7	3.4	3.2	3.2	3.5	3.4	3.2	3.5	3.5
Savoy	3.9	3.9	3.1	2.8	4.3	4.9	5.0	4.6	3.8	3.8	3.5	3.7
Sharon	4.3	4.0	3.9	3.5	3.4	3.0	3.9	3.9	3.4	3.6	3.4	3.8
Shelburne Falls	2.6	2.9	2.7	2.8	4.1	3.5	3.8	4.0	3.3	3.8	3.4	3.3
Somerset	4.18	3.94	4.33	3.90	3.51	3.01	3.41	3.65	3.33	3.62	3.70	3.75
Somerville	3.6	3.5	3.7	3.6	3.5	3.2	3.6	3.4	3.7	3.4	3.5	3.6
Southampton	3.9	3.9	4.0	3.8	4.2	4.1	4.3	4.3	4.3	4.1	3.8	3.6
Southboro	4.34	4.30	4.32	3.85	3.39	3.45	3.59	3.62	3.74	3.51	3.92	4.06
Southbridge	3.6	3.8	3.85	3.6	4.0	2.85	3.9	3.7	3.8	3.6	3.7	3.5
Springfield	3.46	3.64	3.61	2.97	3.36	3.45	4.19	3.96	3.72	3.57	3.26	3.32
Sterling	3.5	3.7	3.7	3.3	3.4	3.5	3.8	3.8	3.4	3.5	3.6	3.8
Stoneham	3.9	4.0	3.9	3.8	3.4	3.7	3.5	3.6	3.5	3.4	3.3	3.6
Taunton	4.73	4.32	4.43	4.07	3.70	3.21	3.80	3.77	3.75	3.84	3.89	4.16
Templeton	3.3	3.3	3.6	2.9	3.05	2.95	3.7	3.85	3.4	2.85	3.45	3.45
Turners Falls	3.3	2.9	3.5	2.9	3.4	3.1	3.5	3.8	3.7	3.0	3.1	3.3
Vineyard Haven	3.9	3.7	4.1	3.5	3.4	2.9	2.6	3.4	2.6	4.1	3.9	4.2
Walpole	3.8	3.4	3.6	3.4	3.3	2.8	4.0	3.7	3.4	3.5	3.2	3.6
Waltham	3.65	3.49	3.61	3.53	3.43	3.33	3.70	3.62	3.76	3.44	3.54	3.48
Wareham	4.2	4.3	4.9	3.8	3.8	3.0	3.3	3.7	3.3	3.7	3.5	4.0
Warren	3.3	3.1	3.8	3.0	3.0	3.0	4.1	4.4	3.3	3.3	3.3	3.0
Webster	3.64	3.82	4.09	3.36	3.34	3.31	3.63	3.73	3.59	3.23	3.36	3.73
Wenham	3.46	3.28	3.48	3.30	3.56	3.62	3.80	3.50	3.67	3.46	3.62	3.40
Westborough	3.79	3.97	3.98	3.42	3.56	3.38	3.64	3.81	3.50	3.57	3.81	3.54
West Brookfield	3.1	3.1	3.5	3.1	3.1	3.2	4.3	4.3	3.6	3.4	3.2	3.1
Westfield	4.2	4.4	4.0	3.7	3.8	3.8	4.4	4.8	4.2	4.0	4.1	4.1
West Granville	3.9	4.2	3.9	4.2	3.8	3.2	5.1	5.2	4.1	4.1	2.8	3.0
Westminster	4.2	4.1	4.1	4.0	4.5	3.8	3.9	4.4	4.2	3.9	4.4	3.9
Weston	3.9	3.9	4.1	3.5	3.3	3.7	3.7	3.6	3.7	3.2	3.6	3.6
Williamsburg	3.1	3.1	3.5	3.1	4.0	3.4	4.1	3.9	4.1	3.9	3.7	3.7
Williamstown	2.73	2.52	3.00	2.63	3.12	3.43	4.12	4.12	3.50	2.93	2.77	2.96
Winchendon	3.4	3.2	3.5	3.2	3.3	3.4	4.0	4.3	4.0	3.2	3.5	3.4
Winchester	3.6	3.5	3.6	3.0	3.0	3.3	3.3	3.6	3.4	3.0	3.5	3.5
Woods Hole	3.7	3.85	4.0	3.6	3.1	2.6	3.2	3.1	2.8	3.85	3.4	3.8
Worcester	3.34	3.41	3.62	3.20	3.22	3.11	3.59	3.61	3.54	3.24	3.49	3.41
Worthington	3.5	4.2	3.7	3.2	4.4	3.8	4.7	4.0	4.6	3.1	3.7	3.9

MEAN MONTHLY RAINFALL OF SOUTHERN NEW ENGLAND.

Connecticut.

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bridgeport	4.02	3.72	4.35	3.54	3.89	3.20	4.83	4.48	3.76	4.11	3.43	4.05
Burlington (a)	3.4	3.5	3.5	3.8	3.9	3.4	5.0	4.7	4.1	4.0	3.7	3.4
Burlington (b)	4.5	4.3	4.45	4.25	4.1	3.7	4.5	4.6	4.1	4.4	4.5	3.7
Canton	3.93	3.79	3.80	3.59	3.92	3.70	4.46	4.23	4.23	4.06	3.64	3.94
Colchester	4.7	4.3	4.7	4.2	3.9	3.2	4.0	4.5	3.6	4.2	3.9	4.3
Cream Hill	4.1	3.6	3.5	4.0	4.3	4.35	3.95	4.2	3.5	3.95	3.55	3.6
Danielson	4.5	4.1	4.2	3.1	3.3	3.2	3.55	4.1	4.0	3.3	3.95	3.7
Enfield	3.3	3.4	3.3	3.4	3.9	4.2	4.3	3.7	4.6	3.5	3.5	3.6
Falls Village	3.30	3.48	3.40	3.05	3.79	3.59	4.55	4.14	4.44	3.31	3.25	3.49
Greenwich	3.70	3.57	3.71	3.29	3.63	3.26	4.14	4.34	3.50	3.71	3.21	3.57
Hartford	3.55	3.50	3.65	3.37	3.63	3.11	4.26	4.28	3.81	3.73	3.50	3.61
Hartland	4.6	4.5	4.3	2.7	3.8	4.0	4.9	5.1	4.1	4.2	4.4	4.0
Lake Konomoc	4.1	4.3	4.4	2.8	3.8	2.9	3.35	4.05	3.4	3.7	3.8	4.3
Mansfield	3.9	3.8	4.2	3.4	3.3	3.2	4.4	3.9	3.5	3.7	3.3	3.6
Middletown	4.08	4.01	4.33	3.52	3.81	3.19	4.05	4.14	3.64	4.05	3.71	4.10
Nepaug	4.4	3.8	4.1	3.6	3.9	3.2	4.6	4.6	4.5	4.1	3.6	3.7
New Haven	4.01	3.92	4.03	3.46	3.80	3.14	4.24	3.92	3.52	3.71	3.22	3.90
New London	4.12	3.88	3.90	3.54	3.54	3.11	3.45	3.86	3.39	3.64	3.41	3.74
Newtown	4.0	4.0	4.0	3.7	4.1	3.2	4.5	4.2	4.1	3.5	3.8	4.0
North Grosvenor Dale	4.1	4.0	4.2	3.5	3.5	3.2	3.9	3.8	3.5	3.4	3.5	3.8
Norwalk	3.73	3.82	4.17	3.28	3.87	3.10	4.59	4.68	3.82	3.97	3.29	3.80
Norwich	3.87	3.55	3.93	3.56	3.31	3.01	3.61	3.91	3.32	3.49	3.31	3.77
Simsbury	3.8	3.6	3.75	3.2	3.5	3.3	4.05	4.0	3.9	3.8	3.4	3.7
Southington	3.78	3.61	4.00	3.00	3.56	3.01	3.94	4.02	3.67	3.51	3.28	3.87
Voluntown	4.34	4.27	4.28	3.81	3.46	3.10	3.85	3.88	3.58	3.70	3.81	4.24
Wallingford	4.53	4.47	4.16	3.62	3.90	3.32	4.06	3.71	3.54	3.77	3.67	4.45
Waterbury	4.23	4.21	4.07	3.51	3.88	3.45	4.54	4.35	3.69	3.85	3.33	4.16

MEAN MONTHLY RAINFALL OF SOUTHERN NEW ENGLAND.

Rhode Island.

Station.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Block Island	3.83	3.68	3.90	3.61	3.49	2.64	3.04	3.45	2.68	3.52	3.59	3.78
Bristol	4.17	4.05	4.14	3.63	3.22	3.00	2.96	3.35	2.88	3.29	3.43	3.76
Foster	4.3	4.2	4.6	4.1	3.8	3.2	4.0	4.1	4.1	3.7	3.9	4.4
Hope	4.70	4.35	4.48	4.11	3.71	3.27	3.87	3.91	3.79	3.83	4.00	4.30
Hopkinton	5.0	4.3	5.1	4.1	3.4	3.7	4.1	4.3	3.6	4.3	4.4	4.5
Kingston	5.21	4.89	5.01	4.51	4.19	3.32	3.54	4.38	3.59	4.31	4.25	4.94
Lonsdale	4.2	4.1	4.0	3.7	3.8	3.3	3.9	3.8	3.6	3.6	3.7	4.0
Narragansett Pier	4.44	4.05	4.56	4.01	3.90	3.08	3.29	3.92	3.27	3.79	3.85	4.07
Pawtucket	4.49	4.42	4.19	3.67	3.66	3.17	3.92	3.86	3.59	3.48	3.42	4.17
Providence	4.78	4.47	4.32	3.86	3.73	3.20	3.75	3.67	3.72	3.61	3.67	4.18
Scituate	4.2	4.1	4.2	3.8	3.8	3.1	3.8	4.2	3.7	3.6	3.6	4.1
South Scituate	4.4	4.2	4.5	4.0	3.6	3.3	4.3	4.2	3.9	3.6	3.85	4.15
Wallum Pond	4.2	3.4	4.0	3.3	3.4	3.6	4.2	3.9	3.4	3.6	4.2	3.5
Woonsocket	4.47	4.10	4.33	3.81	3.76	3.21	4.22	3.91	3.70	3.66	3.86	4.02

THE RAINFALL OF NEW ENGLAND.

Minimum and Maximum Monthly Rainfall of Southern New England.*

BY J. HENRY WEBER.†

Absolute Maximum Monthly Rainfall.

In January (Fig. 1) the maximum has exceeded 6 in. in all portions of the area, with the exception of a small one in the Connecticut Valley in northern Massachusetts. Most of Connecticut, southeastern Massachusetts and Rhode Island have experienced over 9 in., while some portions have had over 10 in. The highest reported at any station is 11.9 in., at Acushnet, Mass.

The maximum in February (Fig. 2) has exceeded 6 in. throughout the entire area. The 8- and 10-in. isohyets are numerous and show very little geographical arrangement, while in January they had been confined almost entirely to the southern portion. Although no station has reported a rainfall in excess of 12 in. (New London, 11.98 in.), it is interesting to note that most of Rhode Island and eastern Connecticut have experienced from 7 to over 8 in. in one storm, namely that of February 11–14, 1886.

In March (Fig. 3) there is less variation throughout the area than in the preceding months. The prevailing amount for the region is in the neighborhood of 8 in. The southern portion has recorded a slightly higher rainfall than the northern, a few stations there having values slightly over 10 in.

April (Fig. 4) is the first month to report a maximum exceeding 12 in. Such values are found in the interior of Connecticut and Rhode Island. For the remainder of the region, the prevailing values are in the vicinity of 8 to 10 in. Williamstown is the only station not to have recorded 6 in. of rainfall in April.

In May (Fig. 5) the absolute maximum values for southern New England are lower than any other month of the year. The prevailing values are in the vicinity of 7 to 8 in., while the extremes are 5.8 in. at Williamstown and 10.5 in. at Provincetown. Bridgeport is the only other station to have had more than 10 in.

June (Fig. 6) shows a higher and more varied maximum than in any of the preceding months. In the northern and western portions of the region the prevailing values are between 10 and 14 in., and in the southern and eastern, from 8 to 10 in. The major portion of the stations on the

*Editor's Note: Previously printed in this Journal, Vol. XLII, No. 4, December, 1928, pp. 414–430.
†Formerly Clark University, Worcester, Mass., now Department of Operation and Maintenance, The Panama Canal, Balboa Heights, C. Z.

southern coast have maximum values under 8 in., Block Island, with 12.9 in. being the only notable exception. The highest values are 14.3 and 14.1 in. at Southampton and North Dana, Mass., respectively.

In July (Fig. 7) the variation of the maximum rainfall is extreme. The highest maximum, 19.90 in. at Southington, Conn., and the lowest maximum, 5.05 in. at Nantucket, are the greatest and least maxima for any month; this, in itself, is a remarkable contrast.

In the Connecticut River lowland and to the westward in Connecticut, the values are decidedly in excess of those of any preceding or following month, a number of stations in the southern part of Connecticut reporting values in excess of 18 in. From Southington to New London, Conn., a distance of 45 miles, the maximum varies from 19.9 in. to 7.1 in. The greater portion of this abnormally high rainfall fell in three storms, in July, 1897. Following is an excerpt from the New England Section of the Climate and Crop Service of the Weather Bureau, July, 1897:

> The history of the regular and voluntary observation service in New England furnishes no parallel to the precipitation record of July, 1897. The extremes in the total fall for the month were 2.02 in. at Orono, Me., and 19.90 in. at Southington, Conn., a most remarkable variance considering the comparatively small area of the district.
>
> Three great storms, namely, those of the 13th and 14th, 22nd and 29th produced the bulk of the abnormal large totals in the interior of New England (the coast sections averaged about normal). The first storm will probably stand as a memorable and distinctive one in Connecticut and western Massachusetts. The downpour lasted from thirty to thirty-six hours, and at the close of the storm it was found that from five to over ten inches had fallen in many sections, exceeding all records for any single storm, Southington, Conn., had 10.30 in. (in 33 hours); Bridgeport, Conn., 9.39; Windsor and Hartford, Conn., 9.22 and 9.17 in. respectively, while at the mouth of the Connecticut River the measurements were normal. Farther north through western Massachusetts and into Vermont, New Hampshire and Maine the amounts reached five and six inches, but along the eastern coast the precipitation was very small.
>
> The second heaviest storm of the month came on the 22nd. This had remarkable local irregularities in Connecticut, where the precipitation was the greatest. In some localities the storm resembled a cloudburst and the consequent floods were worse than for many years. Finally on the 29th, the third deluge occurred, accompanied by severe electrical disturbances. These storms created flood conditions in various regions, which assumed altogether colossal proportions. Several lives were lost and the damage done amounted to thousands and thousands of dollars.
>
> On the 16th, the Connecticut River at Hartford, Conn., was nearly twenty feet above low water mark while on the 30th it was but slightly lower. These are said to have been the first real floods in this river in July since 1683, according to Professor Hart of Trinity College.

In August (Fig. 8) the maximum is much less varied than in July, and the isohyets show very little geographical arrangement. The highest is 13.1 in. at Colrain, Mass.

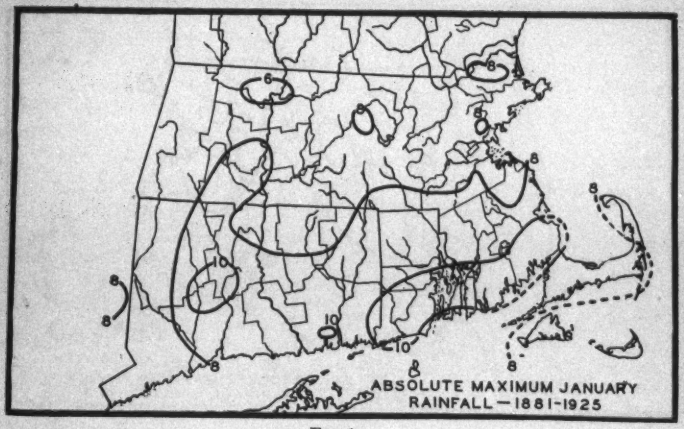

ABSOLUTE MAXIMUM JANUARY
RAINFALL — 1881-1925

FIG. 1.

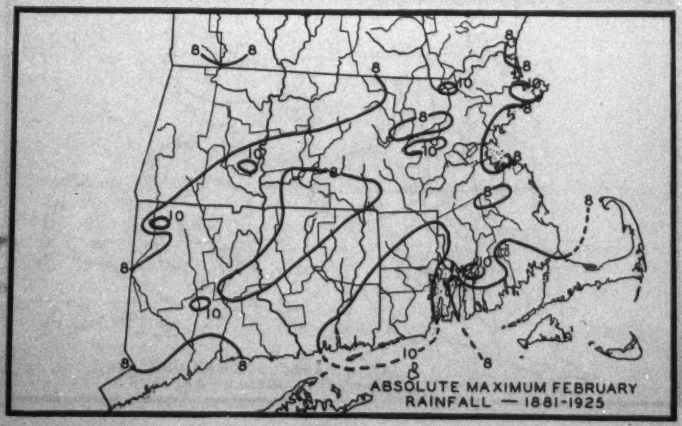

ABSOLUTE MAXIMUM FEBRUARY
RAINFALL — 1881-1925

FIG. 2.

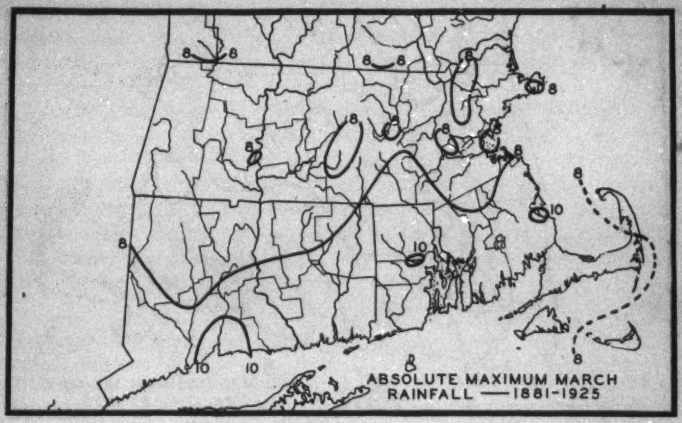

ABSOLUTE MAXIMUM MARCH
RAINFALL —1881-1925

FIG. 3.

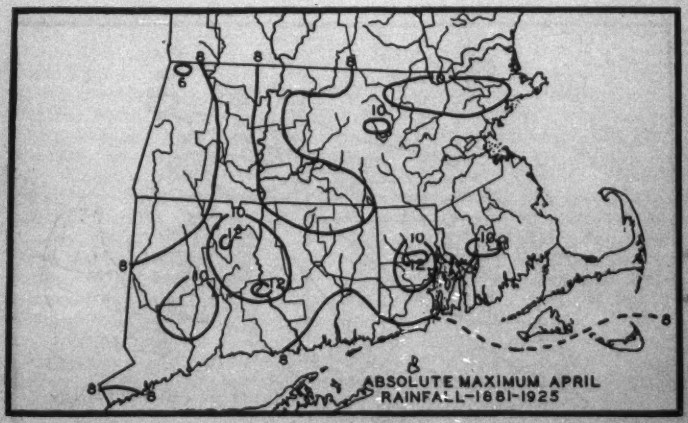

ABSOLUTE MAXIMUM APRIL
RAINFALL-1881-1925

FIG. 4.

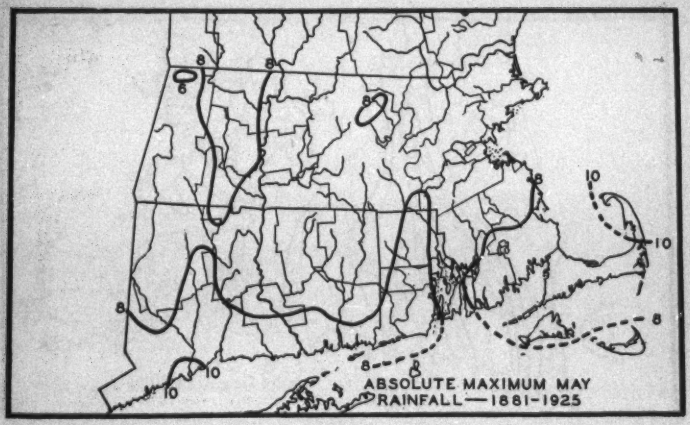

ABSOLUTE MAXIMUM MAY
RAINFALL — 1881-1925

FIG. 5.

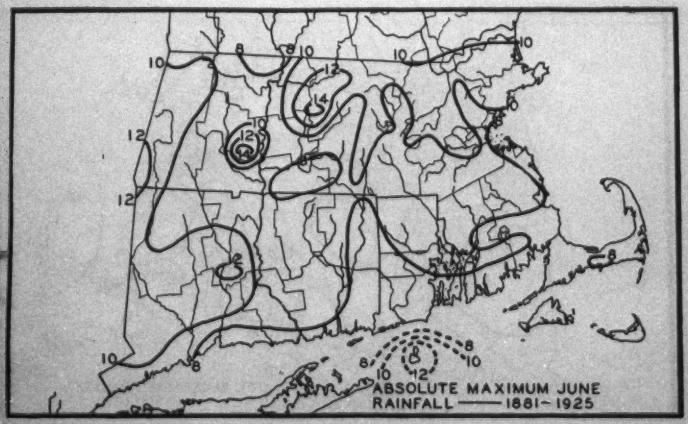

ABSOLUTE MAXIMUM JUNE
RAINFALL — 1881-1925

FIG. 6.

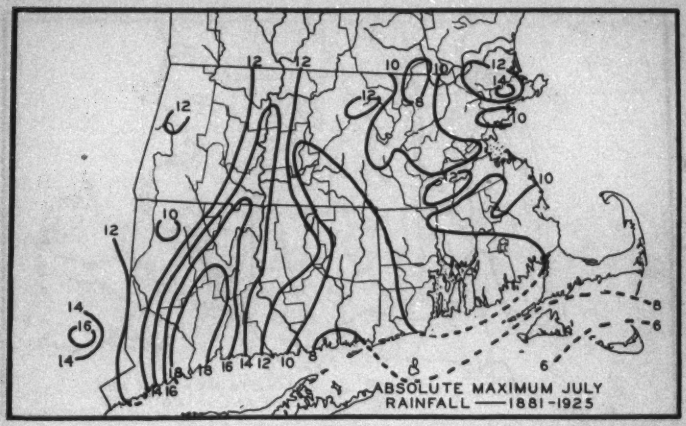

ABSOLUTE MAXIMUM JULY
RAINFALL —— 1881-1925

FIG. 7.

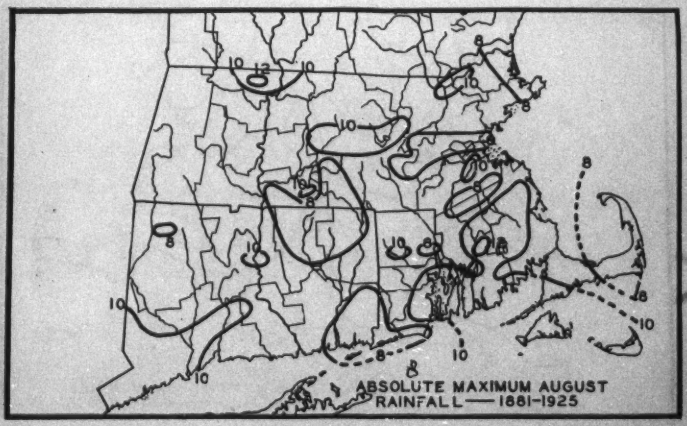

ABSOLUTE MAXIMUM AUGUST
RAINFALL —— 1881-1925

FIG. 8.

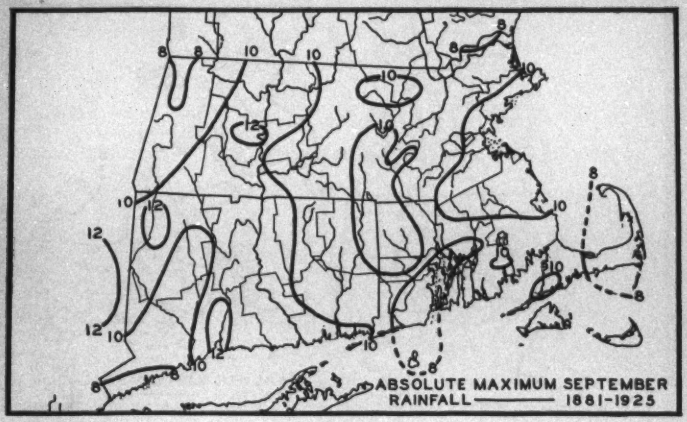

ABSOLUTE MAXIMUM SEPTEMBER
RAINFALL ——— 1881-1925

FIG. 9.

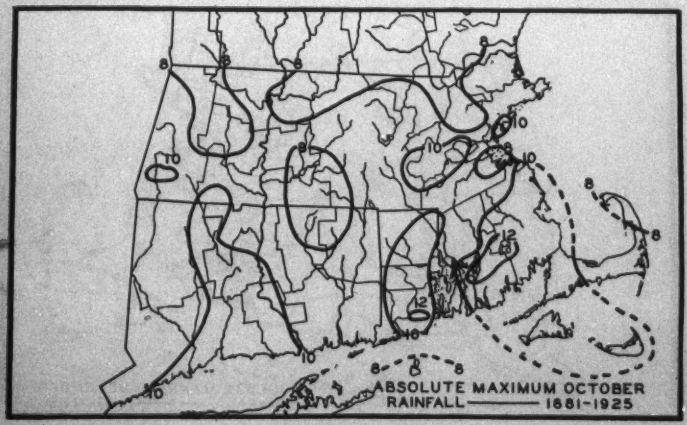

ABSOLUTE MAXIMUM OCTOBER
RAINFALL ——— 1881-1925

FIG. 10.

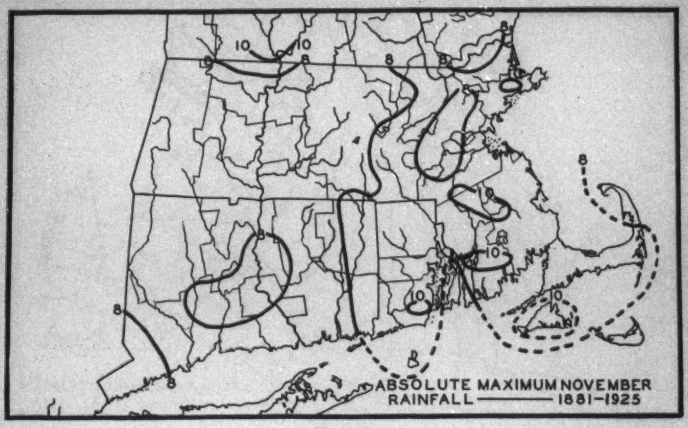

ABSOLUTE MAXIMUM NOVEMBER
RAINFALL ——— 1881-1925

FIG. 11.

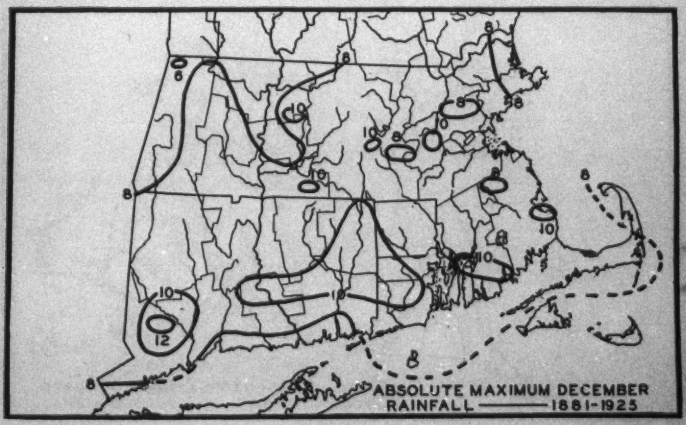
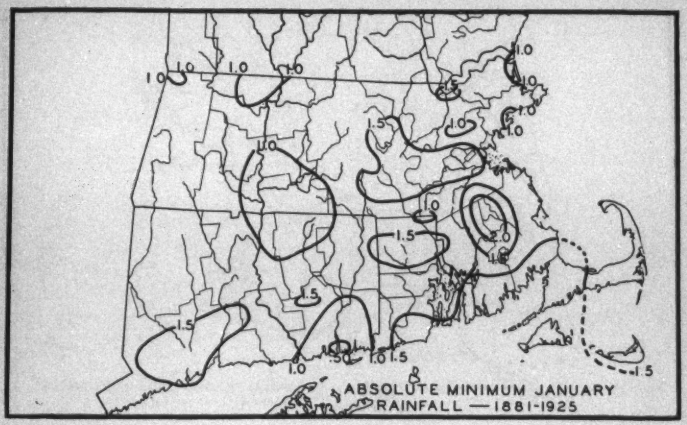

ABSOLUTE MAXIMUM DECEMBER
RAINFALL ——— 1881-1925

FIG. 12.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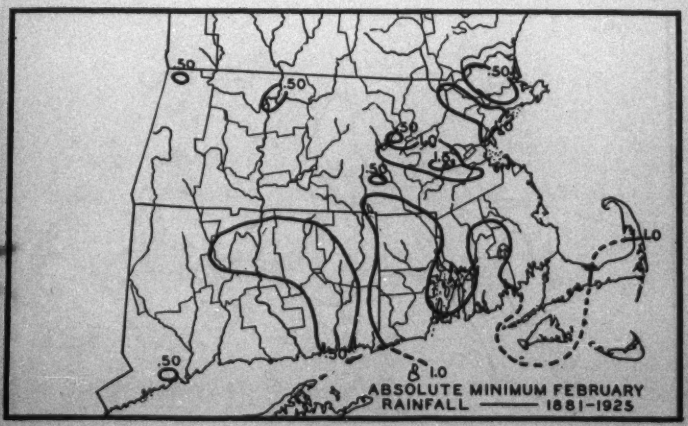
ABSOLUTE MINIMUM JANUARY
RAINFALL — 1881-1925

FIG. 13.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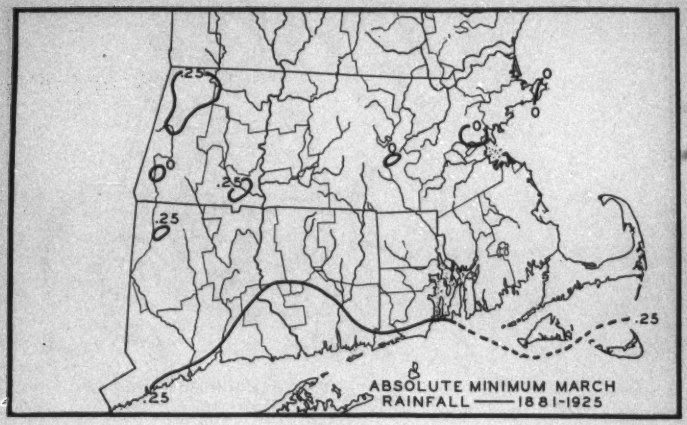
ABSOLUTE MINIMUM FEBRUARY
RAINFALL ——— 1881-1925

FIG. 14.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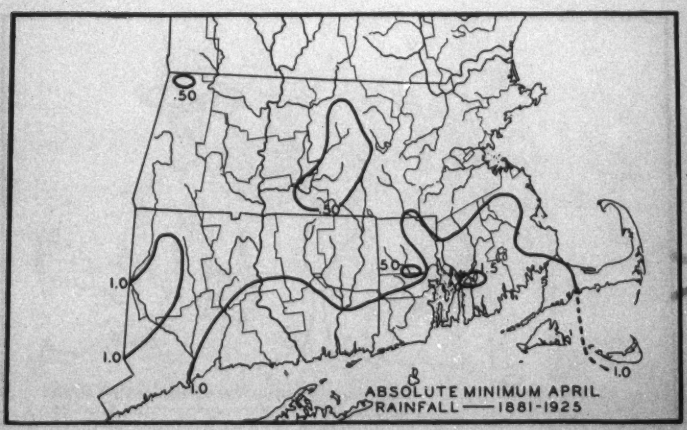
ABSOLUTE MINIMUM MARCH
RAINFALL —— 1881-1925

FIG. 15.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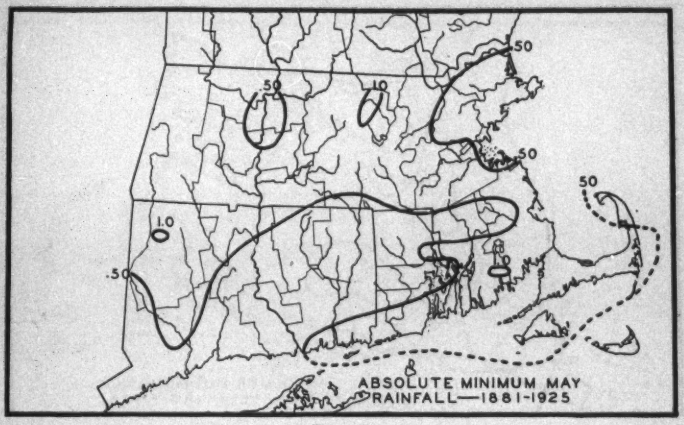
ABSOLUTE MINIMUM APRIL
RAINFALL —— 1881-1925

FIG. 16.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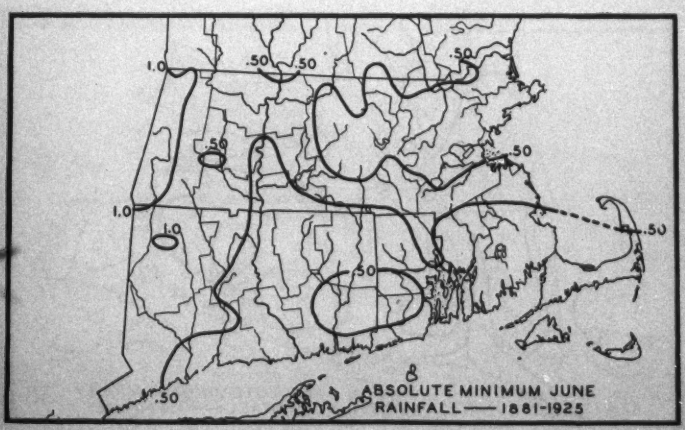
ABSOLUTE MINIMUM MAY
RAINFALL—1881-1925

FIG. 17.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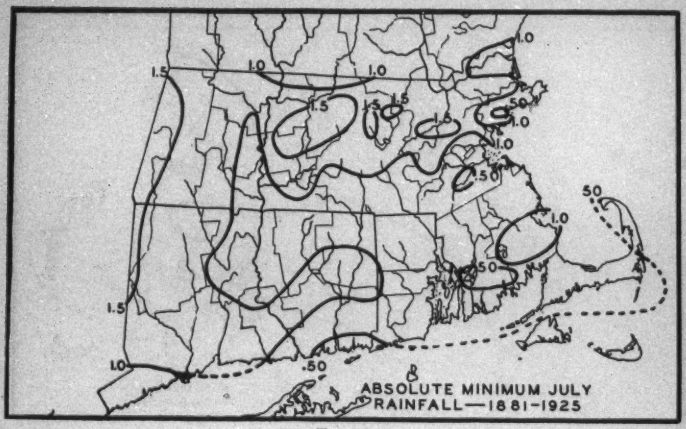
ABSOLUTE MINIMUM JUNE
RAINFALL—1881-1925

FIG. 18.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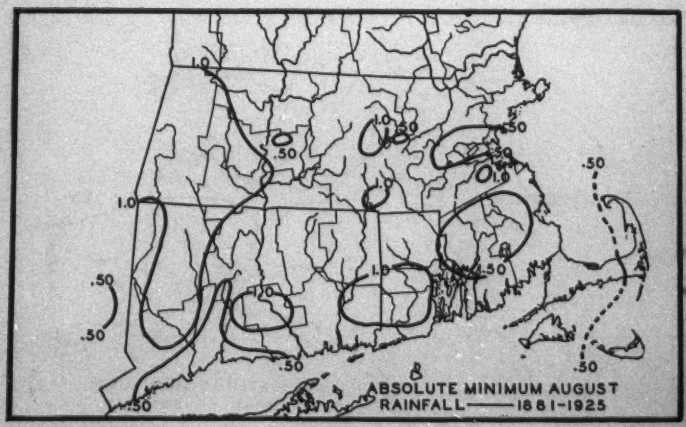
ABSOLUTE MINIMUM JULY
RAINFALL—1881-1925

FIG. 19.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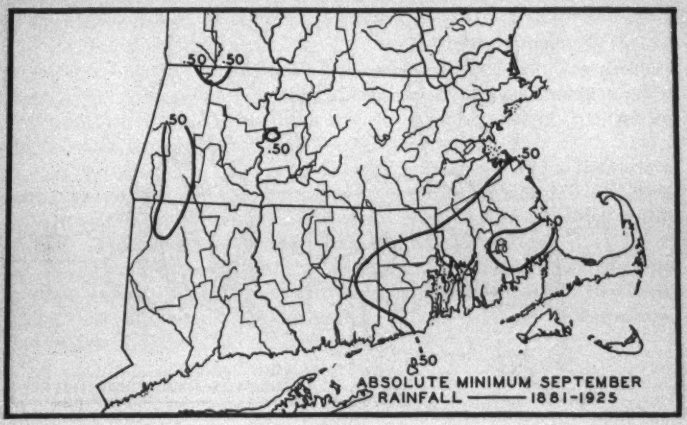
ABSOLUTE MINIMUM AUGUST
RAINFALL——1881-1925

FIG. 20.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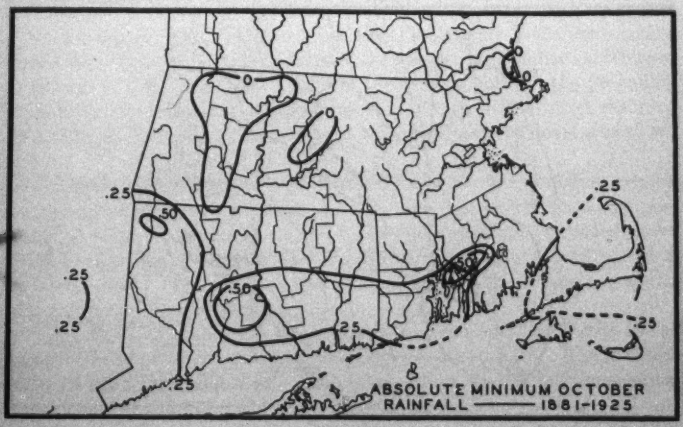
ABSOLUTE MINIMUM SEPTEMBER
RAINFALL ——— 1881-1925

FIG. 21.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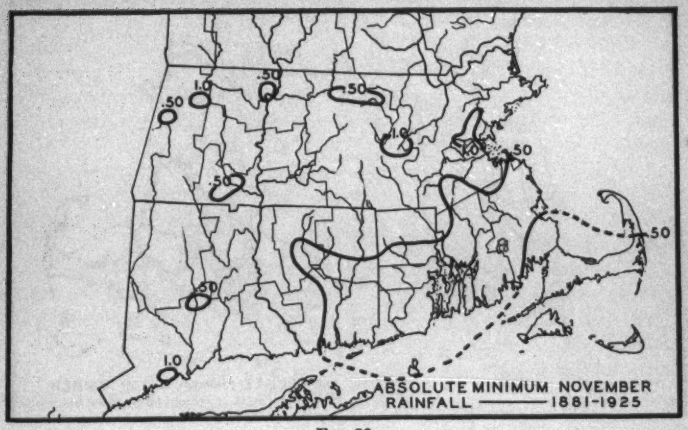
ABSOLUTE MINIMUM OCTOBER
RAINFALL ——— 1881-1925

FIG. 22.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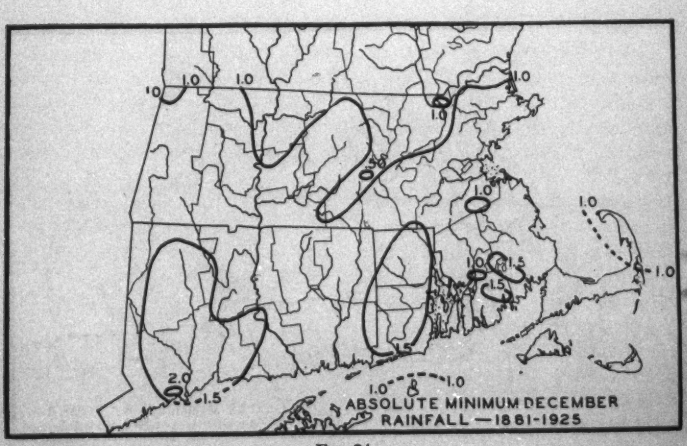
ABSOLUTE MINIMUM NOVEMBER
RAINFALL ——— 1881-1925

FIG. 23.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ABSOLUTE MINIMUM DECEMBER
RAINFALL — 1881-1925

FIG. 24.

The maximum September rainfall (Fig. 9) occurs in the Connecticut valley and to the westward. Here the values are in the neighborhood of 10 to 12 in., with the highest for the month, 13.1 in., at New Haven. Most of the coastal regions have values from 8 to 10 in.

October maximum values (Fig. 10) have a variation similar to that of September but the geographical distribution is different. The greatest rainfall is in the southeastern portion, inland, where the amounts in a few cases, slightly exceed 12 in. With a few exceptions, amounts under 8 in. are found only in the northern and central portions.

In November (Fig. 11) the maximum amounts are found in the eastern part of the region, where the prevailing amounts are from 8 to 10 in. Most of the western portion of the region has not received 8 in. of rainfall in this month. The highest recorded is 11.5 in. at Acushnet, Mass.

The December maximum rainfall (Fig. 12) is greatest in the southern portion, inland, and least in northwestern Massachusetts. Newtown, Conn., has recorded the highest rainfall, 12.3 in., while at Williamstown, the maximum amount is but 5.9 in.

Absolute Minimum Monthly Rainfall.

In January (Fig. 13) no very low minimum rainfalls have been recorded, New London, Conn., being the only station to have had as low as 0.50 in. For the region as a whole, the amounts have not fallen below 1.0 to 1.5 in., while at Taunton, Mass., the lowest recorded in January is up to 2.05 in.

In February (Fig. 14) the minimum at nearly all of the stations has fallen lower than in January. Most of the western portion has experienced a rainfall of 0.50 in. or lower while in the eastern portion, the prevailing minimum amounts are in the neighborhood of 1 in. The lowest recorded is 0.13 in. at Norwich, Conn., while at Natick, Mass., the amount is above 1.5 in.

March (Fig. 15) shows a profound difference in the minimum rainfall in comparison with the previous months. Only the south coast and portions of western Massachusetts and Connecticut, have not recorded under 0.25 in. Many stations in eastern Massachusetts have experienced a rainless month. March, 1915, was the month of lowest rainfall throughout the greater portion of the area.

In April (Fig. 16) the minimum in the southern portion is in the neighborhood of 1.0 in. and in the northern portion, 0.50 in. The lowest is 0.25 in. at Templeton, Mass. Fall River, Mass., is the only long-record station where the minimum has not fallen below 1.5 in.

Nearly all of the area has recorded below 1 in. of rainfall in May (Fig. 17), while a large portion has received under 0.50 in. The lowest amounts are along the western coast of Connecticut with Greenwich reporting the lowest, .01 in.

Nearly all the region east of the Connecticut River has had under 0.50 in. in June (Fig. 18), while many stations report values under 0.25 in. The lowest is 0.09 in. at Haverhill, Mass. For the extreme western portion of Massachusetts and at Cream Hill, Conn., the minimum amount is above 1 in.

In July (Fig. 19) there are considerable local variations, although in general, the southern portion has the lowest amounts; here the amounts have fallen, in general, below 0.50 in. In the northern and western portions the minimum amounts are in the neighborhood of 1.0 to 1.5 in. The lowest recorded is 0.22 in. at Nantucket, Mass.

Throughout the area, August (Fig. 20) shows a lower minimum rainfall than July. The western portions have not experienced below 1 in. while in the remainder of the region the values, in general, are between 0.50 to 1.0 in. The lowest is 0.10 in. at Provincetown.

September (Fig. 21) has a lower minimum rainfall throughout the area than in any preceding month excepting March. Only the southeastern portion and small areas in the western part have always received over 0.50 in. during September. For the remainder of the region the amounts are generally less than 0.25 in.

The October minimum rainfall map (Fig. 22) is next to March in low values. Outside of the southern portion and western Connecticut, the amounts are well below 0.25 in. Many stations in Massachusetts, particularly in the western portion, have had a rainless month. The low rainfall occurred throughout the area in October, 1924.

In November (Fig. 23) most of the southeastern portion has had under 0.50 in. For the remainder of the area the minimum values are, in general, between 0.50 and 1 in. The lowest recorded is 0.13 in. at Turners Falls, Mass.

There are no very low minimum values in December (Fig. 24), Holden, Mass., being the only station to have had an amount below 0.50 in. For the rest of the area the amounts are generally well above 1 in. Bridgeport, Conn., is the only station always to have had at least 2 in. of rainfall in December.

Summary and Conclusion.

The data available furnish satisfactory mean annual rainfall values, with their variations, for most of the southern portion of New England, while more stations are desirable in northern Maine, New Hampshire and Vermont and also in the central portion of the last-named state. It is believed, however, that the essential rainfall features have been shown within these areas.

The seasonal distributions are such that the coastal regions have their greatest mean monthly rainfall in the winter months and the least in the summer, while the far interior has an opposite distribution. Between these two regions, the monthly rainfall distribution is practically uniform.

In southern New England, the mean monthly and seasonal values appear to be of a satisfactory degree of accuracy except in the higher elevations in central and western Massachusetts and portions of western Connecticut. The three types of rainfall distribution noted for the New England region as a whole, are distinctly shown here, most particularly the coastal and the near interior types.

Maximum and minimum values are naturally less satisfactory and are subject to more change with increasing length of record. The period used is sufficiently long to show that any part of southern New England may receive over 10 in. and under 0.25 in. in some months. Maximum values are greatest in the northern and western portions in the summer months, while in winter the maximum values are usually found in the southern portion. The minimum values are not as low during the winter as they are in other seasons. March and October are the only months when rainless conditions have been experienced over even a portion of the area.

THE RAINFALL OF NORTHERN NEW ENGLAND.*

BY GRAGG RICHARDS.†

Mean Seasonal Rainfall.‡

The spring rainfall (Fig. 1) for the greater part of this region ranges from 8 to 11 in. Near the stormier coast it generally amounts to more than 10 in., while falling under 9 in. in northern New Hampshire and Vermont, and in that part of Maine over 100 miles inland. Aside from Mt. Washington, the only high-altitude station, with 18.03 in., Bar Harbor, Me., (12.61 in.) alone receives over 12 in. Areas receiving less than 8 in. are confined to the Lake Champlain region, the upper Connecticut Valley, and northern Maine. West Stewartstown, N. H., (5.8 in.) a valley station behind mountains, shows the lowest rainfall.

In summer the rainfall (Fig. 2), as a whole, is somewhat heavier, mostly between 10 and 12 in. But in contrast to spring conditions, central Maine and both northern and southern New Hampshire and Vermont, now warm and convectively active, receive over 12 in., while stations near the chilly coast, except Bar Harbor (10.2 in.) record slightly under 10 in. Mt. Washington has 28.04 in.; other stations receiving over 14 in. are Woodstock, N. H., Victory and Readsboro, Vt. The only station under 8 in. is Houlton, Me. (7.7 in.).

The general distribution of rainfall for autumn (Fig. 3) resembles that for spring. Parts of the Maine coast receive over 12 in. as compared with 8 to 10 in. for the interior. For New Hampshire and Vermont, the relative precipitation is similar to that for both spring and summer, individual stations showing, in general, less rain than in summer, but more than in spring. Besides Mt. Washington (22.49 in.), the only stations recording over 13 in. are Woodland, Me., (13.1 in.) and Somerset, Vt.,(13.4 in.). Kineo, Me., (7.4 in.) and Fitzdale (7.7 in.) and Ryegate, Vt., (7.9 in.) are the low-record stations, all in rain-shadow locations.

Precipitation along the coast is heavier in winter (Fig. 4) than in either spring or autumn, while becoming the lowest of any season for the interior. Greater storminess on the coast and the lower temperatures of the interior are responsible. Mt. Washington (13.65 in.) no longer stands out in contrast to the coastal stations of Bar Harbor, Belfast and Calais, Me., and Somerset, Vt., (all 13.6 in.). The upper Connecticut Valley, Fitzdale, and Guildhall, Vt., (5.1 in.) and the Lake Champlain region — Burlington, Vt., (5.15 in.) — persist as lowland areas of light precipitation in the rain shadows of the neighboring highlands.

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*Editor's Note: A Project of the Clark University Graduate School of Geography, under the supervision of Charles F. Brooks. Previously printed in this JOURNAL, Vol. XLII, No. 4, December, 1928, pp. 431–456.

†Mining Geologist, Detroit, Michigan.

‡Reference should be made to the general account of the seasonal rainfall of New England, with diagrams and map, in this JOURNAL.

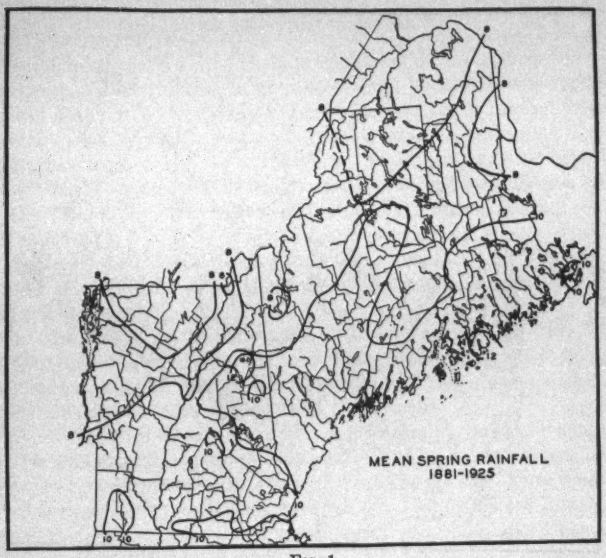
MEAN SPRING RAINFALL
1881-1925

FIG. 1.

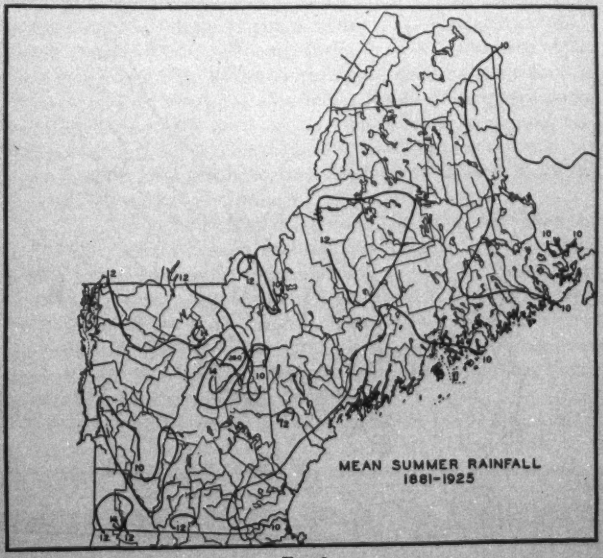
MEAN SUMMER RAINFALL
1881-1925

FIG. 2.

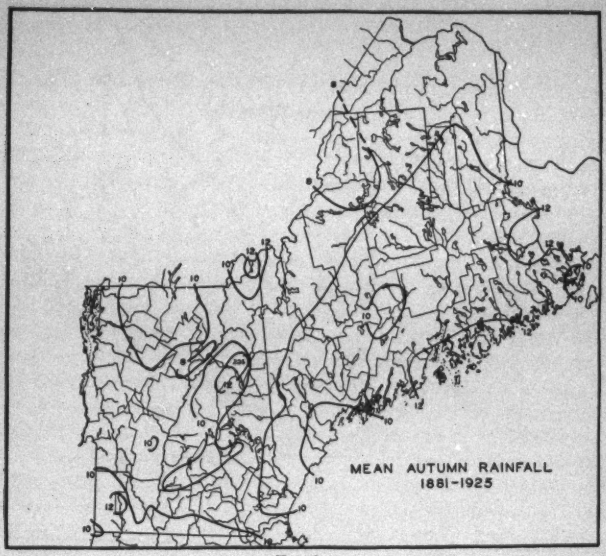
MEAN AUTUMN RAINFALL
1881-1925

FIG. 3.

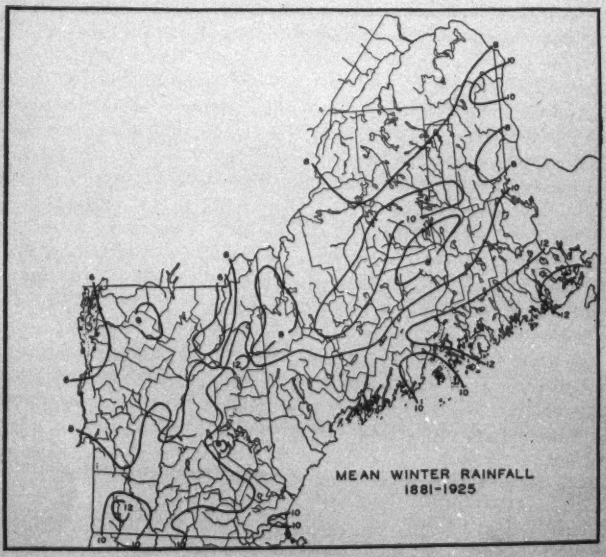
MEAN WINTER RAINFALL
1881-1925

FIG. 4.

Mean Monthly Rainfall.*

For January (Fig. 5), the mean precipitation decreases from the coast inland so that a line from the southwest corner of Vermont to the northeast corner of Maine roughly divides the region into two areas, the southeastern receiving over 3 in. and the northwestern with lighter precipitation. Except for Mt. Washington (4.27 in.) and Somerset, Vt.,(4.8 in.) stations recording over 4.5 in. are confined to the Maine coast. The upper Connecticut Valley, the Lake Champlain region, and probably northern Maine, receive less than 2 in.

February distribution (Fig. 6) practically parallels that for January, precipitation in general being slightly lower as would be expected for the shorter month.

In March (Fig. 7), the coastal belt of Maine receives over 4 in., northern Maine, New Hampshire and most of Vermont, less than 3 in. Mt. Washington and Bar Harbor record over 5 in.; the upper Connecticut Valley and the Lake Champlain region, 2 in. or less.

April (Fig. 8) shows a marked falling off in rainfall, especially along the coast, where no station records over 4 in. The southeastern half of the region, still receives more than 3 in., the northwestern less. Mt. Washington now stands out prominently with 5.94 in. Northeastern Maine, the upper Connecticut Valley and the southern part of the Lake Champlain region are areas of lighter rainfall.

May (Fig. 9) is marked by a nearly uniform distribution of rainfall throughout northern New England. Only Mt. Washington (6.17 in.), the upper Deerfield Valley in southern Vermont and scattered stations in Maine register over 4 in. A belt with breaks, showing less than 3 in,, extends northeastward from Lake Champlain, includes the upper Connecticut Valley, New Hampshire, north of the White Mountains, and northern Maine, so that the coastal belt, as a whole, still has heavier precipitation than the interior. Houlton, Me., and West Stewartstown, N. H., are the only stations showing 2 in. or under.

The prevalence of a rainfall of between 3 and 4 in. continues through June (Fig. 10), but the average precipitation is higher, and areas with over 4 in. now predominate over those with less than 3 in. The former now occur in northern Vermont, New Hampshire and Maine, while continuing in the Deerfield Valley and on Mt. Washington, but the latter have shifted to the lower Connecticut and Merrimac valleys and stations in eastern Maine. Except for Mt. Washington (9.08 in.), Readsboro has the highest mean, 4.9 in. All stations receive over 2.5 in.

The rainfall in the coastal belt remains at between 3 and 4 in. for July (Fig. 11), but increases markedly in the interior, so that much of northwestern Maine and northern New Hampshire, as well as Vermont, record

*Cf. Southern New England in the preceding paper of this Journal. The same principles of seasonal distribution, particularly, more rainfall in winter than in summer on the coast, and more in summer than in winter in the interior, presented by Mr. Weber for southern New England, are seen to apply here.

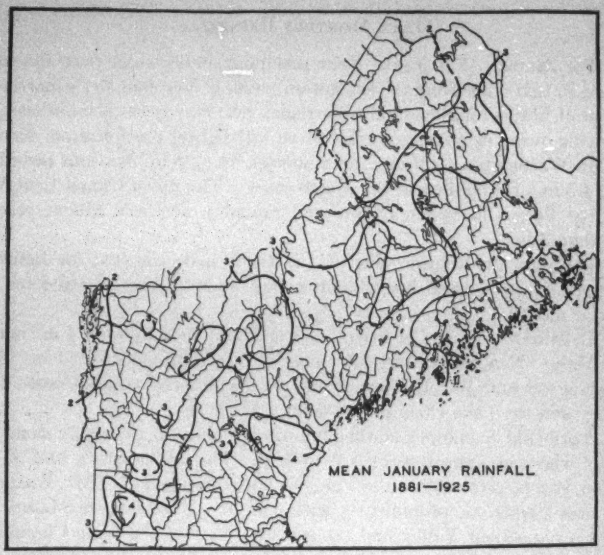
MEAN JANUARY RAINFALL
1881—1925

FIG. 5.

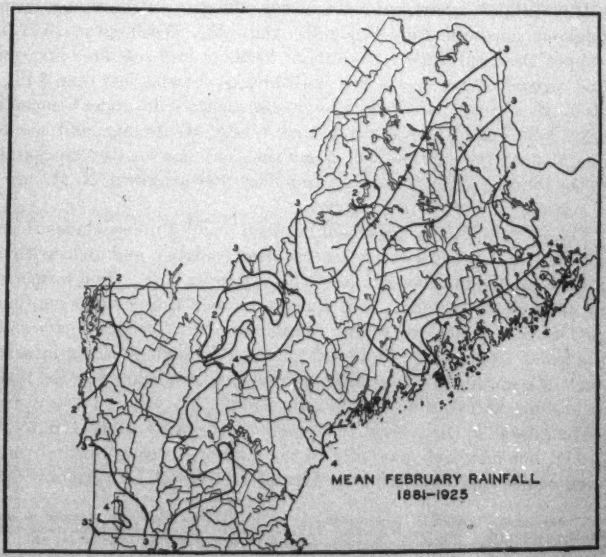
MEAN FEBRUARY RAINFALL
1881–1925

FIG. 6.

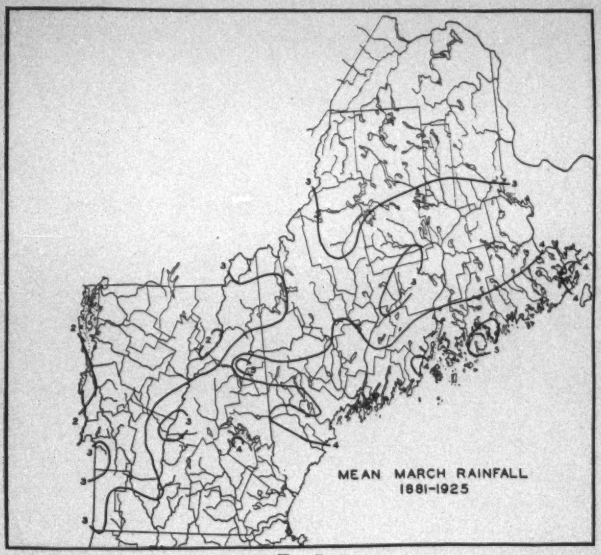
MEAN MARCH RAINFALL
1881-1925

FIG. 7.

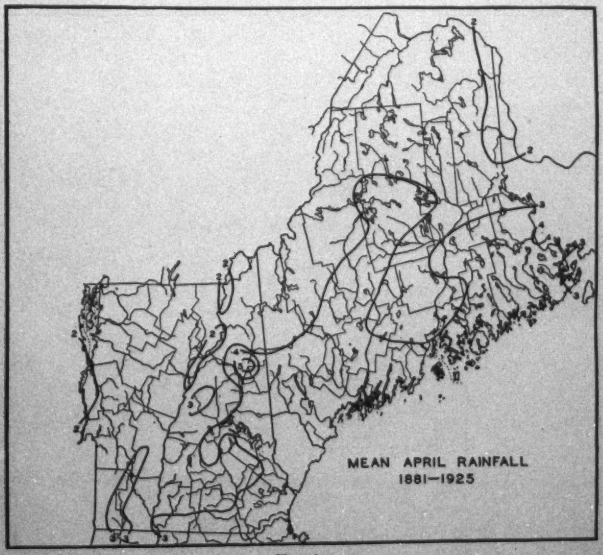
MEAN APRIL RAINFALL
1881—1925

FIG. 8.

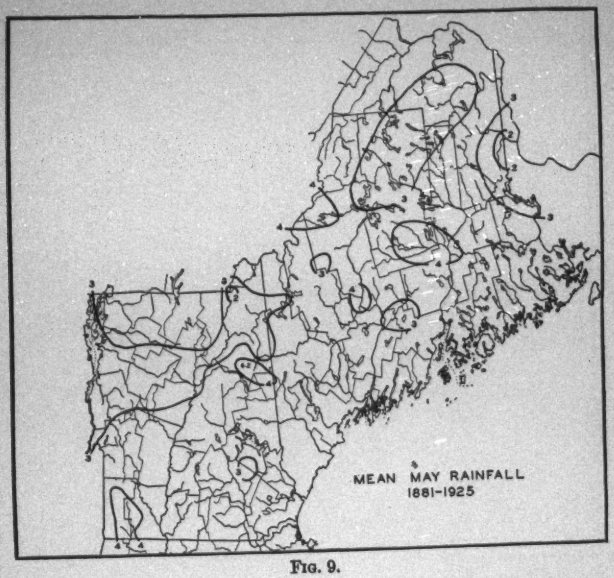

FIG. 9.

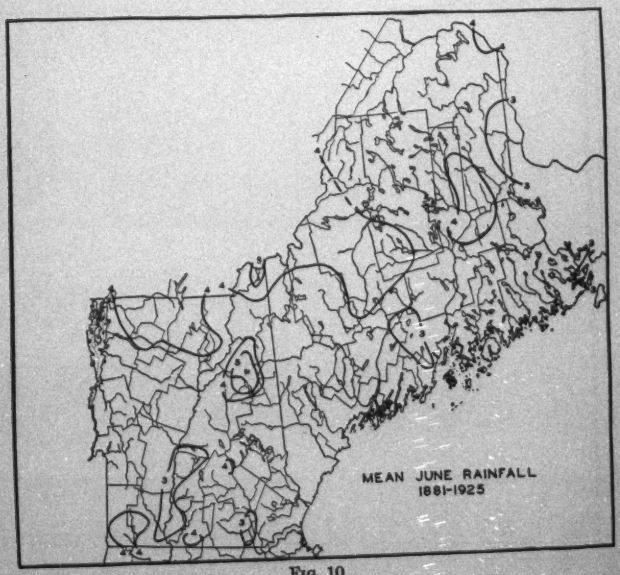

FIG. 10.

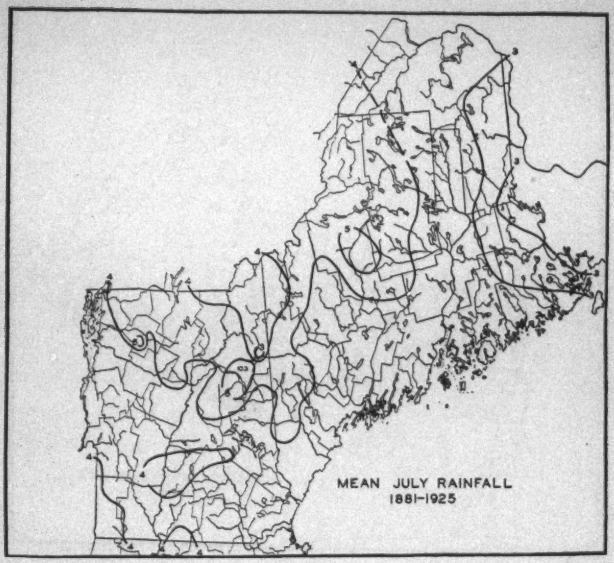
MEAN JULY RAINFALL
1881-1925

FIG. 11.

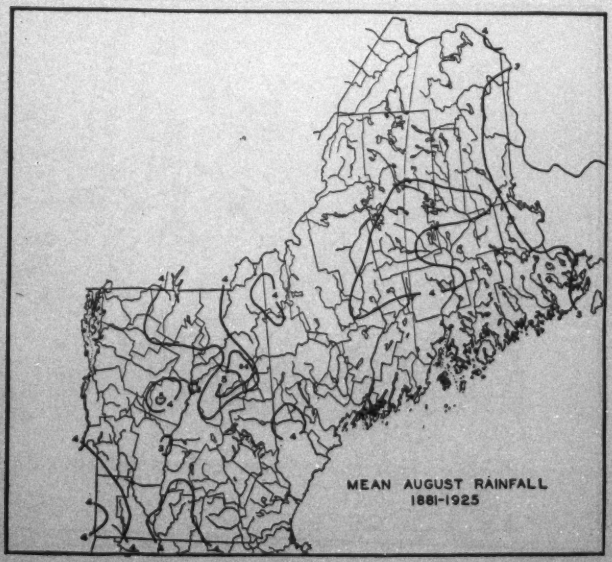
MEAN AUGUST RAINFALL
1881-1925

FIG. 12.

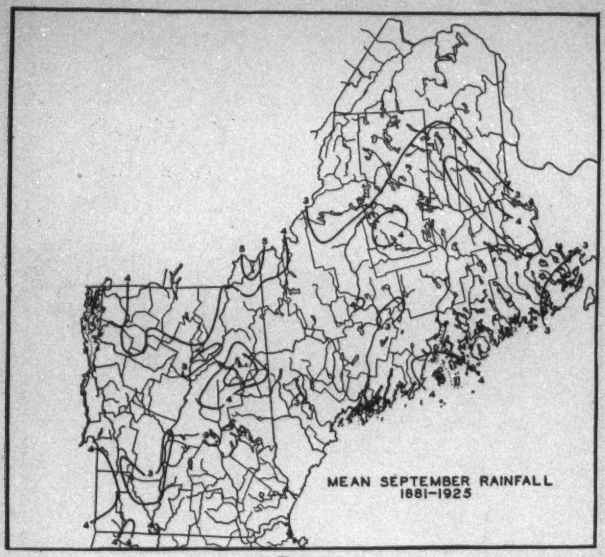
MEAN SEPTEMBER RAINFALL
1881–1925

FIG. 13.

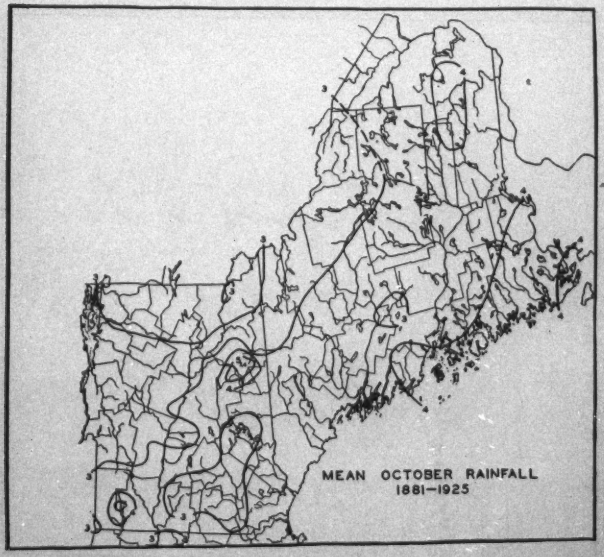
MEAN OCTOBER RAINFALL
1881–1925

FIG. 14.

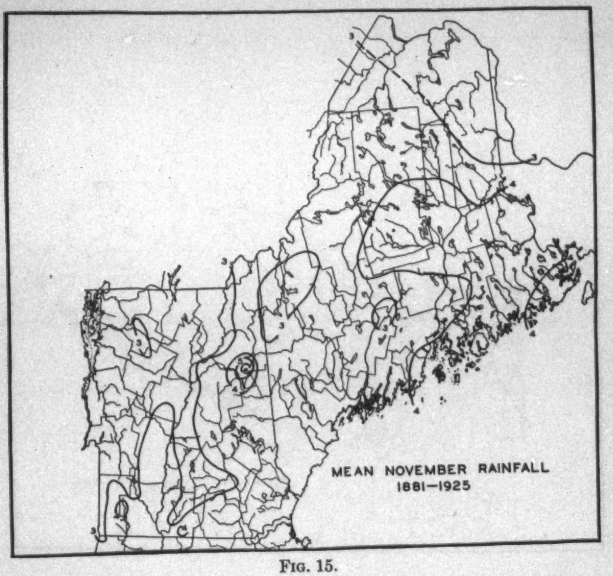
MEAN NOVEMBER RAINFALL
1881–1925

FIG. 15.

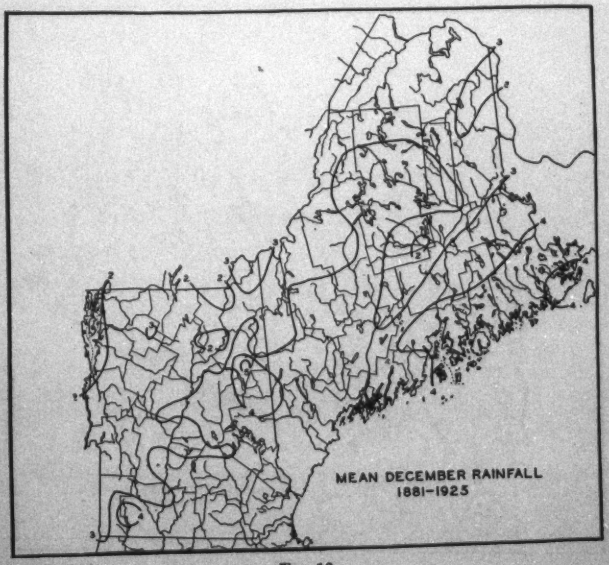
MEAN DECEMBER RAINFALL
1881–1923

FIG. 16.

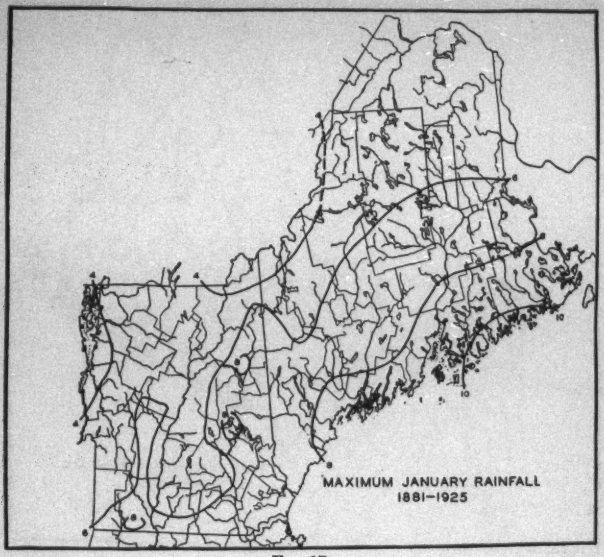
MAXIMUM JANUARY RAINFALL
1881–1925

FIG. 17.

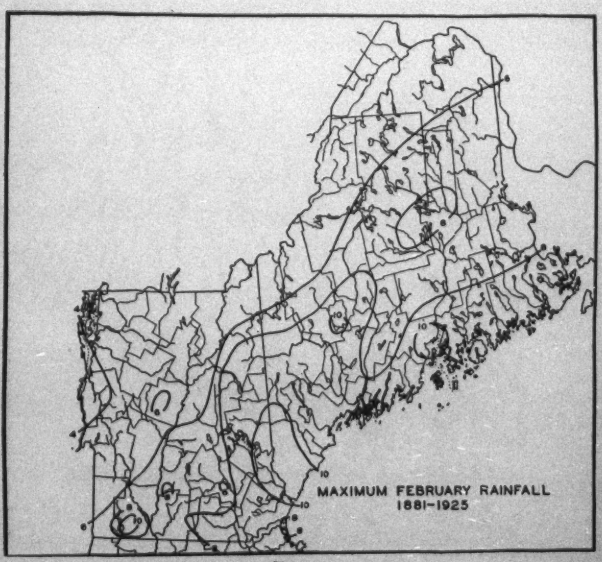
MAXIMUM FEBRUARY RAINFALL
1881–1925

FIG. 18.

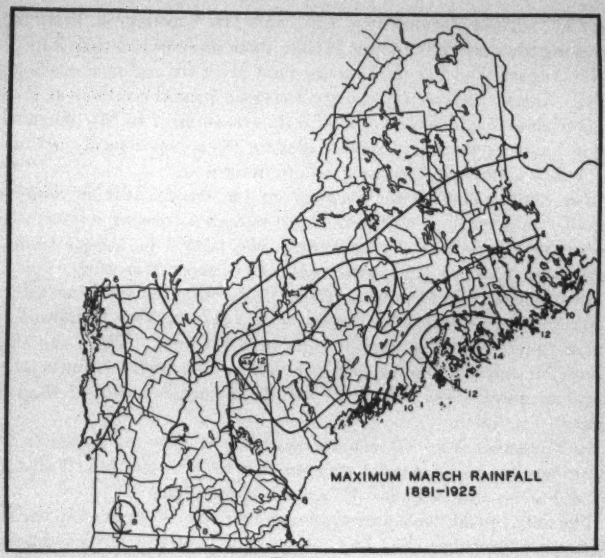
MAXIMUM MARCH RAINFALL
1881-1925

FIG. 19.

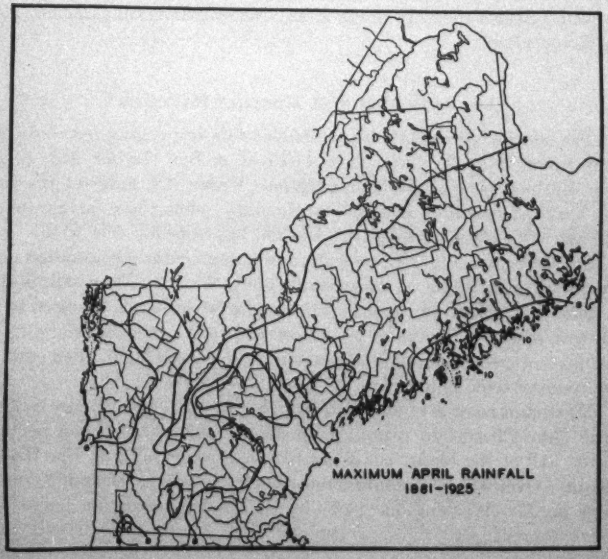
MAXIMUM APRIL RAINFALL
1881-1925

FIG. 20.

over 4 in., several stations over 5 in., and Mt. Washington, 10.34 in. A strip along the eastern border of Maine, alone receives less than 3 in.

By August (Fig. 12), the heaviest rainfall for the region as a whole has passed. Areas with over 4 in. occupy the same general positions as in July, but have shrunk and means of over 5 in. are confined to Mt. Washington (8.62 in.) and its vicinity. Besides eastern Maine, stations in the Connecticut Valley again begin to show values under 3 in.

The rainfall is somewhat heavier on the coastal belt in September (Fig. 13), while much of northern Maine and an increasing number of stations in the Connecticut Valley, receive less than 3 in. Aside from Mt. Washington (8.42 in.), only scattered stations show over 4 in.

In October (Fig. 14), much of the Maine coast receives over 4 in. and the interior, except in the northwest, over 3 in. In New Hampshire and Vermont, precipitation is lighter than in September. The Lake Champlain region, most of the Connecticut Valley, and much of southern New Hampshire, receive less than 3 in. Mt. Washington records 7.45 in. and Somerset, Vt., 5.0 in.

In November (Fig. 15), conditions along the coast are similar to those for October, but many interior stations show a decrease. Mt. Washington (6.62 in.) is the only station with a mean of over 5 in.

The only considerable area receiving over 4 in. is confined to the coast of Maine in December (Fig. 16). Most of the interior has a lighter precipitation than 3 in., and Burlington, Vt., (1.85 in.) and stations in the upper Connecticut Valley fall under 2 in. Mt. Washington (5.22 in.) alone receives over 5 in.

Absolute Maximum Monthly Rainfall.*

The heaviest precipitation recorded for January at long-record stations in the region (Fig. 17) varies from 11.15 in. at Bar Harbor, Me., to 3.59 in. at Burlington, Vt. Roughly, stations within 100 miles of the coast have received over 6 in. in some one January, while those farther inland, have not. No station, except Bar Harbor, has recorded over 10 in.

For February (Fig. 18), the extremes in maximum precipitation occur in Vermont — 12.74 in. at Jacksonville and 3.86 in. at Cornwall, both in the same year, 1900. A line from the southwest corner of Vermont to the northeast corner of Maine serves rather accurately as a boundary, inland of which not over 6 in. of precipitation is to be expected. Few stations have received over 10 in.

Maximum records of less than 6 in., for March (Fig. 19), are confined to the Lake Champlain region, upper Connecticut Valley, and northern Maine. All of the Maine coast has received over 8 in., and Bar Harbor, 14.37 in. Over 9 in. has not been recorded in New Hampshire or Vermont, except on Mt. Washington (14.52 in.). The low-maximum long-record

*Cf. Southern New England in the preceding paper of this Journal.

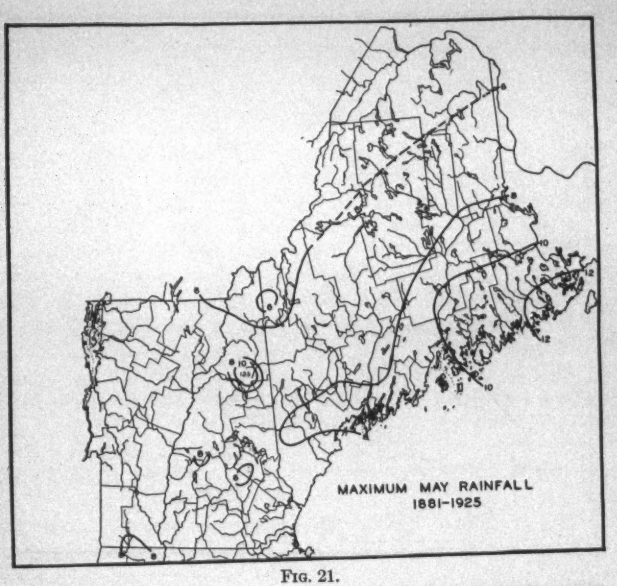
MAXIMUM MAY RAINFALL
1881-1925

FIG. 21.

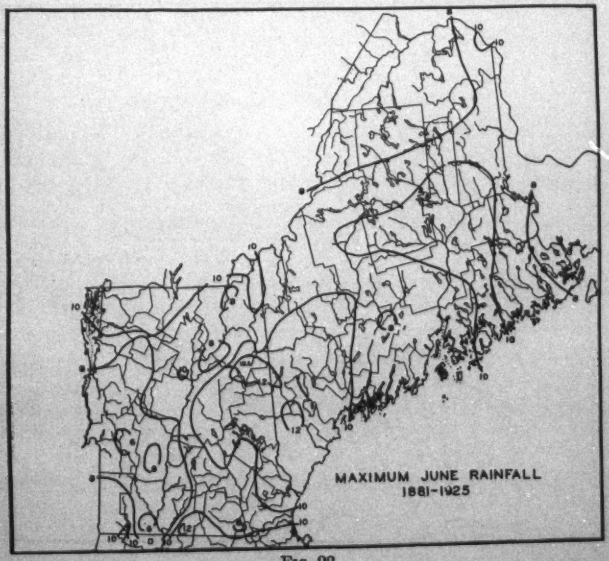
MAXIMUM JUNE RAINFALL
1881-1925

FIG. 22.

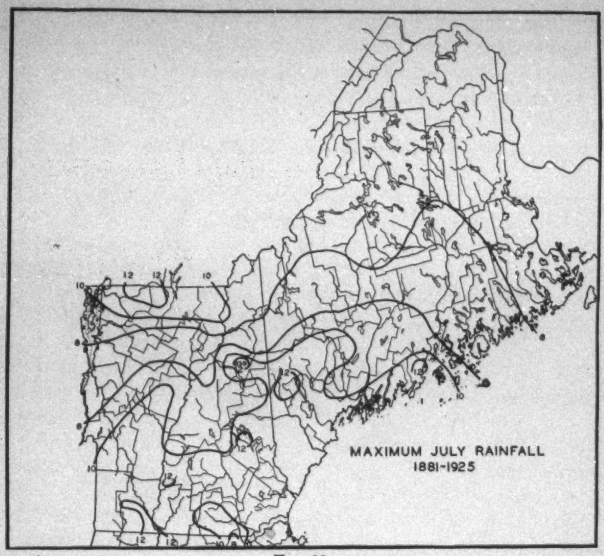
MAXIMUM JULY RAINFALL
1881-1925

FIG. 23.

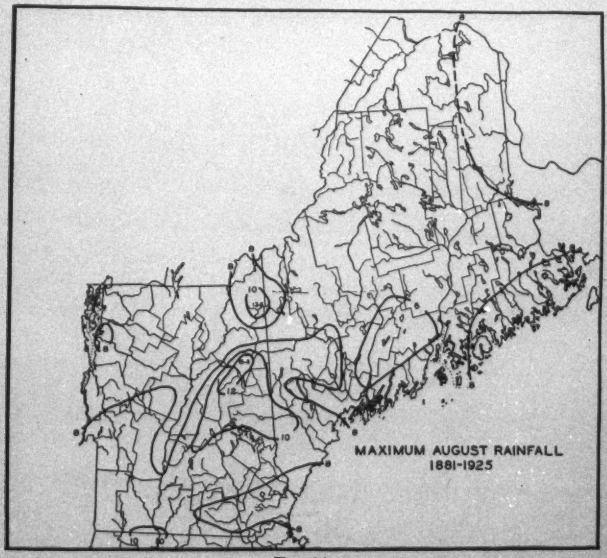
MAXIMUM AUGUST RAINFALL
1881-1925

FIG. 24.

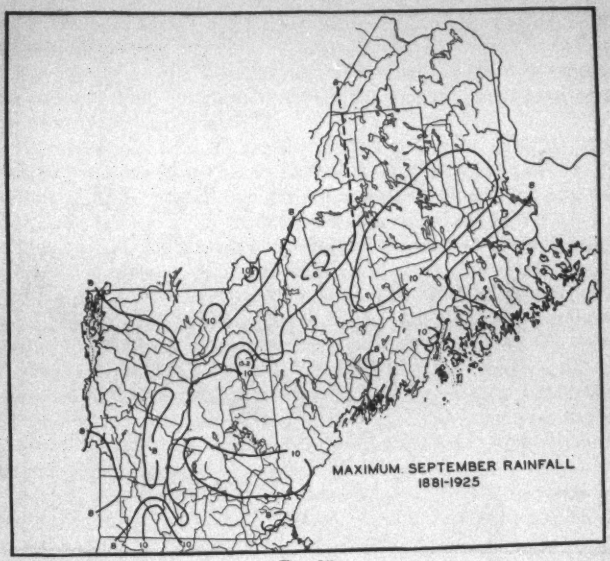
MAXIMUM SEPTEMBER RAINFALL
1881-1925

FIG. 25.

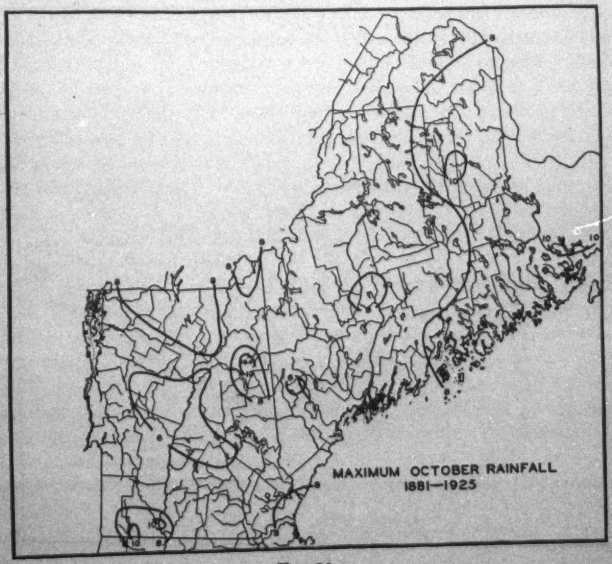
MAXIMUM OCTOBER RAINFALL
1881—1925

FIG. 26.

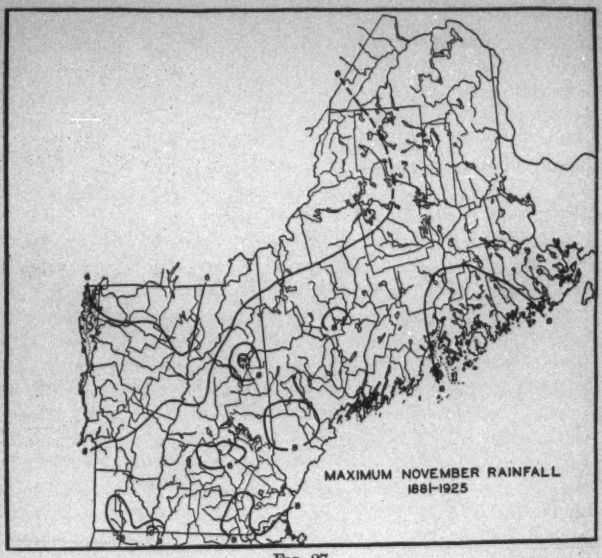
MAXIMUM NOVEMBER RAINFALL
1881-1925

FIG. 27.

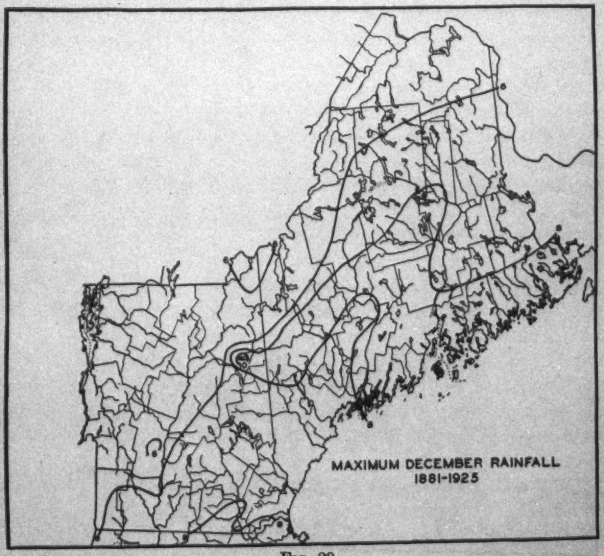
MAXIMUM DECEMBER RAINFALL
1881-1925

FIG. 28.

stations are both in the Lake Champlain region — Burlington, 4.53 in. and Cornwall, 4.55 in.

For April (Fig. 20), there has been little change in the 6-in. boundary of maximum rainfall, but falls of over 8 in. are confined to the coast, except for scattered interior stations.

Precipitation of over 10 in. is limited to Bar Harbor, Me., Mt. Washington and stations to the south, and to Jacksonville, Vt., Cornish, Me., recording 11.52 in. Practically the entire region has received over 5 in., Upper Dam, Me., (4.98 in.) being the low long-record station.

May rainfall (Fig. 21) has exceeded 6 in. in nearly all of northern New England, Upper Dam, Me., (5.49 in.) again being the low-maximum long-record station. Little of New Hampshire and Vermont, excepting Mt. Washington (12.50 in.), has received over 8 in. Eastport, Me., has the high record of 13.22 in., and most of the Maine coast has received over 8 in.

June (Fig. 22) shows a very irregular distribution of maxima, but most long-record stations register over 9 in., and many over 10 in. Mt. Washington comes into prominence with 18.46 in. Halifax and West Rutland, Vt., record their highest rainfall of under 6 in. in June, 1922, a month of maximum rainfall in much of northern New England.

All long-record stations, except Bar Harbor, Me., (6.55 in.) show maxima of over 7 in. in July (Fig. 23), many over 10 in., and several over 12 in. The maximum for Mt. Washington is 23.90 in., followed by Vernon, Vt., with 13.65 in.

August maxima (Fig. 24) of over 10 in. are confined practically to northern and central New Hampshire, including Mt. Washington (15.39 in.) and Errol (13.60 in.). An area in south central Maine, including Belfast, Fairfield, Winslow and Gardiner, has not received as much as 6 in.

Records of over 10 in. are well distributed over the region in September (Fig. 25), and all long-record stations show over 6 in. Mt. Washington (15.23 in.) alone records over 12 in.

In October (Fig. 26), but a few scattered stations show over 10 in. rainfall, and only Mt. Washington (18.38 in.) over 11 in. Eastern Maine is the only considerable area having received over 8 in. Hanover, N. H., has a maximum of but 5.49 in.

The only stations having recorded over 10 in. in November (Fig. 27), are Mt. Washington (17.55 in.) and Vernon, Vt., (10.12 in.). Most of the region has not received 8 in., but generally over 6 in., except for some Lake Champlain and upper Connecticut Valley stations.

In December (Fig. 28), some regularity in the distribution of maximum precipitation becomes evident again, the southeastern part of the region having received over 6 in., the northwestern less. Mt. Washington (15.95 in.), is the only station with a record of over 10 in., and an excess over 8 in. is limited practically to southern Maine. The maximum for Cornwall, Vt., is but 4.54 in.

Absolute Minimum Monthly Rainfall.*

Nearly all of northern New England has experienced Januarys with less than 1.0 in. of precipitation (Fig. 29), but few parts have not received at least 0.5 in. While most of the immediate coastal belt has not recorded less than 1.0 in., Portland, Me., (1.83 in.) is the only station with a minimum of over 1.5 in. Fairfield, Me., received but 0.31 in. in January, 1896, a month of minimum precipitation at many stations.

In February (Fig. 30), no station shows a minimum of as much as 1.5 in., and few, mostly near the Maine coast, in excess of 1.0 in. A belt from Lake Champlain to Durham, N. H., has received less than 0.5 in. Northfield, Vt., has a low record of 0.18 in., in February, 1901; that month and February, 1895, accounting for many of the minima.

Practically all of the region has had a March precipitation (Fig. 31) of under 0.5 in. March, 1915, was a month of light rainfall, Halifax, Vt., and Manchester, N. H., recording no precipitation, and neighboring stations, as well as Bar Harbor, Me., but a trace. Oldtown, Me., however, received 1.05 in. in the same month.

For April (Fig. 32), most stations record minima of between 0.5 and 1.0 in. Portland and Lewiston, Me., and Keene, N. H., have always received at least 1.0 in. during this month. No rain fell at Upper Dam, Me., in April, 1899, and but 0.07 in. on Mt. Washington in April, 1872.

Many stations show minima for May (Fig. 33) of less than 0.5 in. Manchester, N. H., (1.26 in.), is the only long-record station that has not received less than 1.0 in. No rain fell at Upper Dam, Me., and but a trace at Burlington, Vt., in May, 1903, a month of generally light rainfall. In other years, Errol, N. H., had a rainless May, and Bar Harbor, Me., but a trace.

For June (Fig. 34), most of the northwestern part of the region, has not received less than 1.0 in., though under 1.5 in., while parts of the Maine coast, as well as of southern New Hampshire and Vermont, have low records of less than 0.5 in. But 0.10 in. fell at Bar Harbor, Me., and at Concord, N. H., in June, 1913, a month of generally light rainfall, as was also June, 1912.

Manchester, N. H., (0.31 in.) is the only station with a minimum of under 0.5 in. in July (Fig. 35). The Maine coast, a strip across southern New Hampshire and Vermont, and Burlington on Lake Champlain have records of less than 1.0 in. For the rest of northern New England, minima at long-record stations vary from 1.0 to 1.5 in.

A large area in central Maine, has received under 0.5 in. in August (Fig. 36), but a trace falling at Orono in August, 1899. The rest of the region has low records of 0.5 to 1.0 in., except for Burlington, Vt., (1.05 in.) and some stations in central New Hampshire.

In September (Fig. 37), practically the whole region has received less

*Cf. Southern New England in the preceding paper of this Journal.

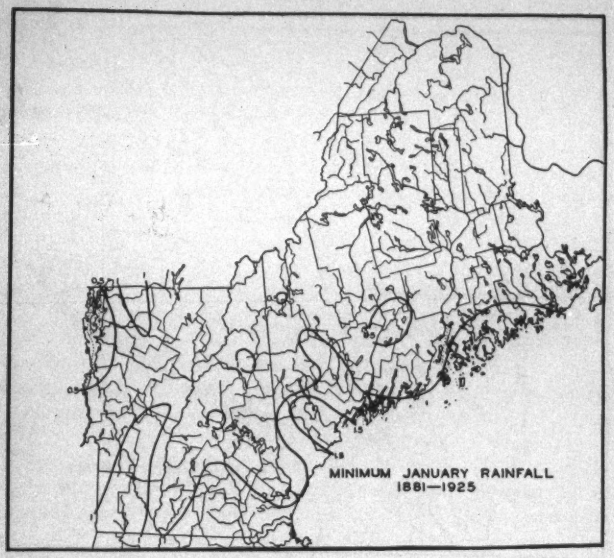
MINIMUM JANUARY RAINFALL
1881—1925

FIG. 29.

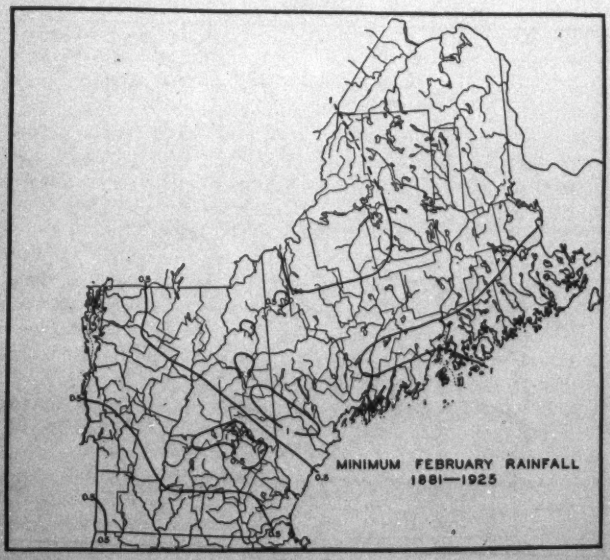
MINIMUM FEBRUARY RAINFALL
1881—1925

FIG. 30.

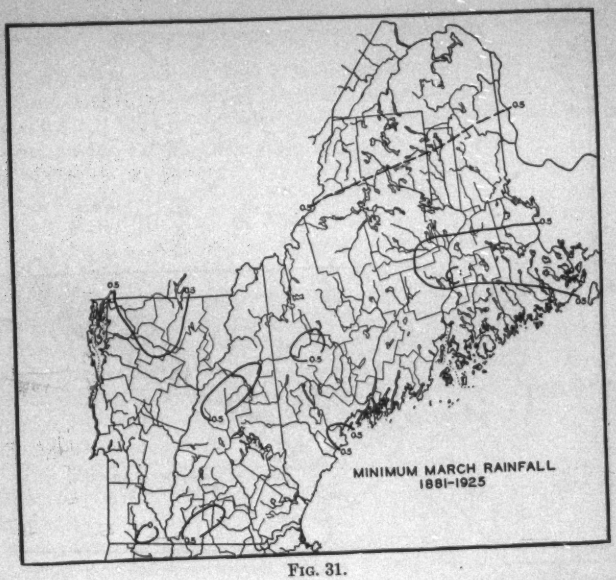
MINIMUM MARCH RAINFALL
1881-1925

FIG. 31.

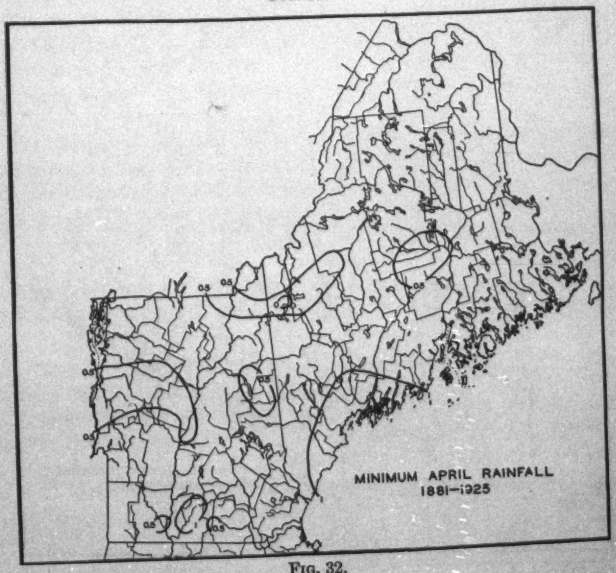
MINIMUM APRIL RAINFALL
1881-1925

FIG. 32.

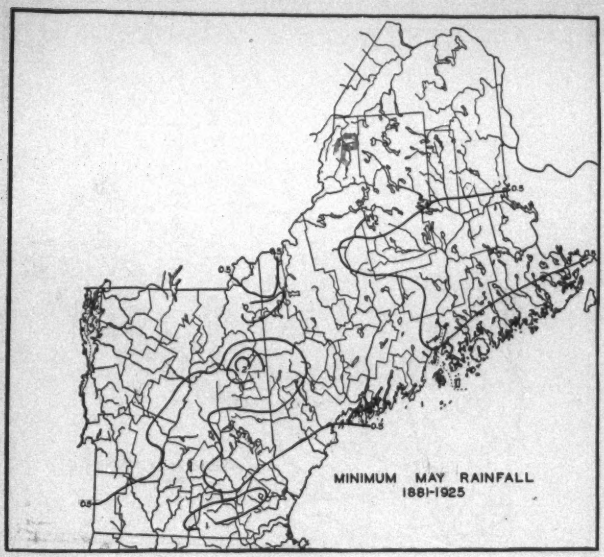
MINIMUM MAY RAINFALL
1881-1925

FIG. 33.

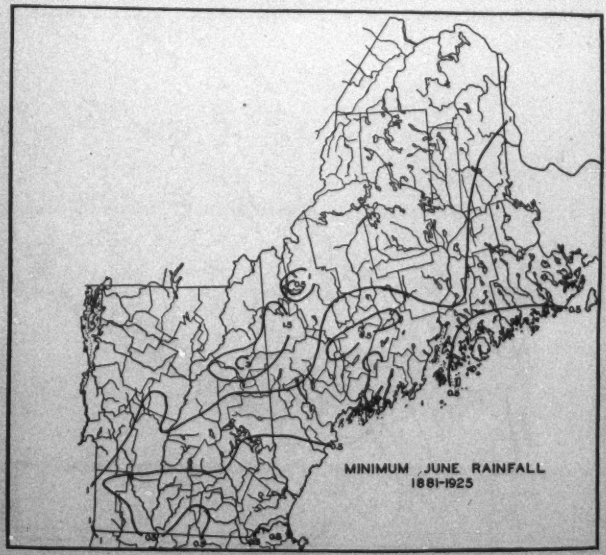
MINIMUM JUNE RAINFALL
1881-1925

FIG. 34.

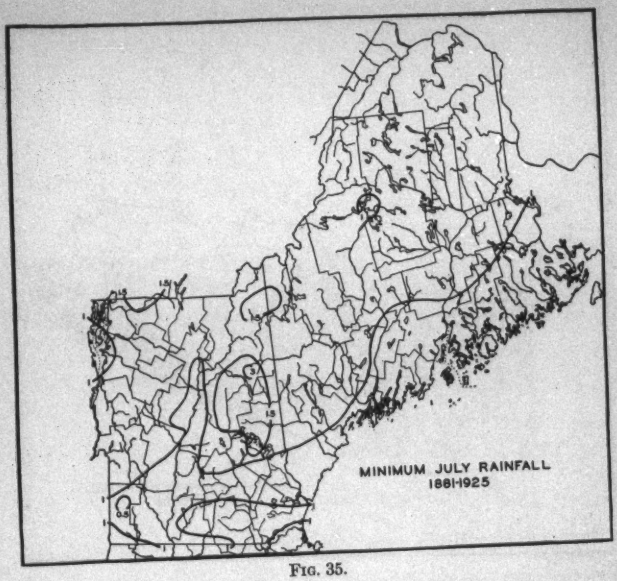
MINIMUM JULY RAINFALL
1881-1925

FIG. 35.

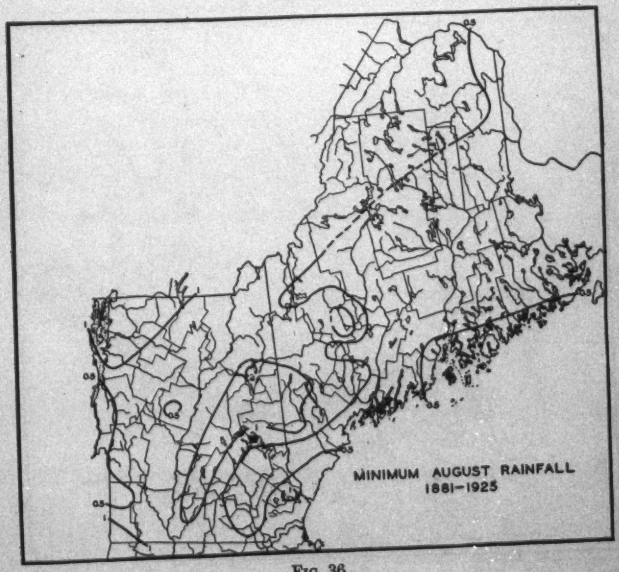
MINIMUM AUGUST RAINFALL
1881-1925

FIG. 36.

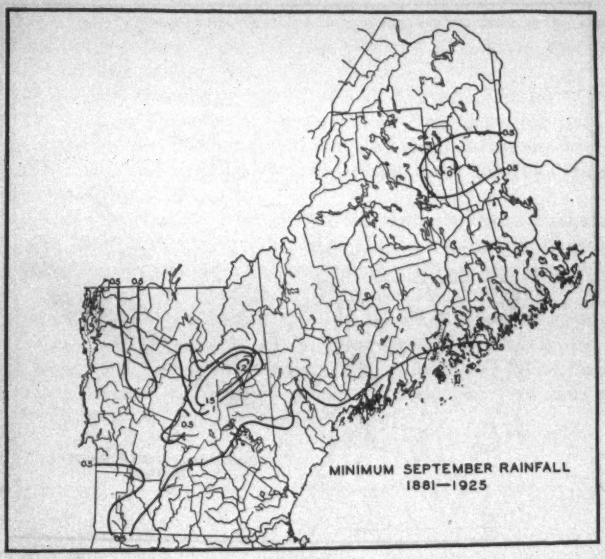
MINIMUM SEPTEMBER RAINFALL
1881—1925

FIG. 37.

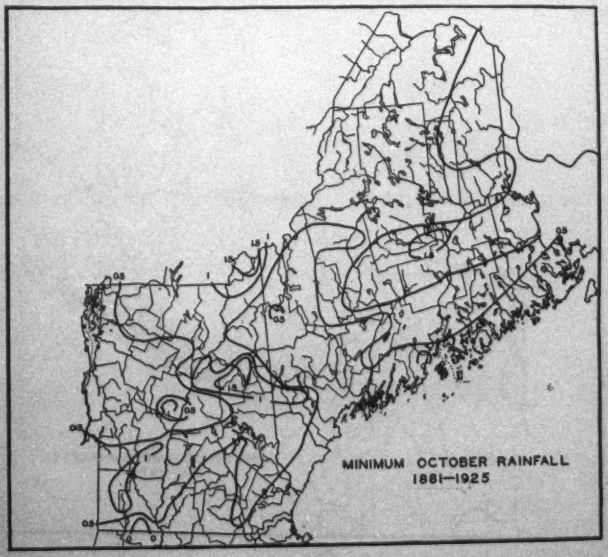
MINIMUM OCTOBER RAINFALL
1881—1925

FIG. 38.

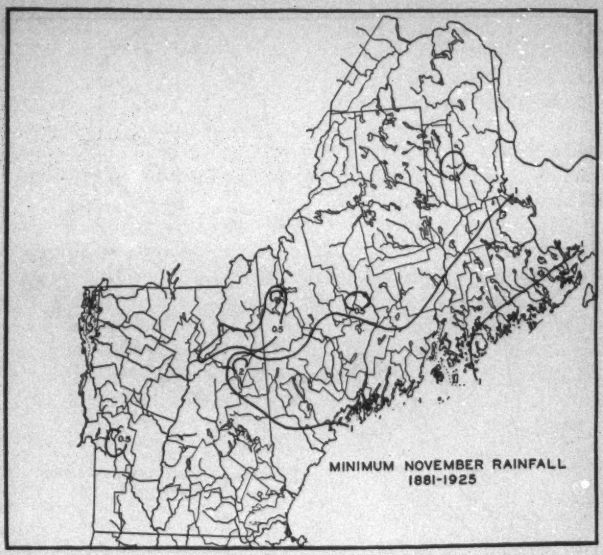
MINIMUM NOVEMBER RAINFALL
1881-1925

FIG. 39.

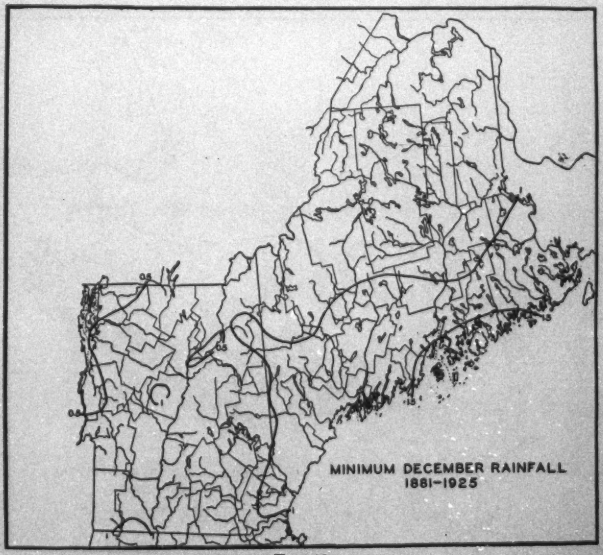
MINIMUM DECEMBER RAINFALL
1881-1925

FIG. 40.

than 1.0 in., but minima of less than 0.5 in. are confined largely to the Maine coast and southern New Hampshire and Vermont. At Patten, Me., September, 1917, was rainless.

Minima vary irregularly from no rainfall to over 1.5 in. for October (Fig. 38), but the Maine coast, southern New Hampshire and much of Vermont, have records falling below 0.5 in. No precipitation was recorded at Camden, Me., and at Halifax, Vt., in October, 1924, and but a trace at Fitzwilliam, N. H.

In November (Fig. 39), a rather wide belt along the Maine coast shows minima of from 1.0 to 1.5 in., while the rest of the region, except for a few scattered stations with lower values, has received not less than 0.5 in. Upper Dam, Me., records no rain for November, 1903.

The belt of minima between 1.0 and 1.5 in. still persists along the Maine coast in December (Fig. 40), but Bar Harbor has not recorded less than 1.95 in. For the rest of the region, minima fall below 1.0 in., but not under 0.5 in., except for Fitzdale, Vt., 0.24 in. in December, 1914, and Cornwall, Vt., 0.38 in., in December, 1892.

AVERAGE RAINFALL TABLES FOR NORTHERN NEW ENGLAND.*

BY GRAGG RICHARDS.†

The numerical data on which were based the maps and discussion presented in the preceding paper of this JOURNAL are presented in the following tables:

MEAN SEASONAL RAINFALL.
Adjusted to 1881–1925.

Maine.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Ashland	7.5	10.1	9.6	7.6	34.8
Azischos Dam	8.5	12.1	9.5	6.7	36.8
Bar Harbor	12.6	10.2	12.6	13.6	49.0.
Belfast	10.4	10.2	10.9	13.6	45.1
Calais	11.7	10.5	11.9	13.6	47.7
Camden	11.0	9.3	12.9	9.2	42.4
Cornish	11.65	12.19	11.46	11.56	46.86
Danforth	8.9	9.8	10.7	10.6	40.0
Eastport	9.70	8.82	9.39	11.03	38.94
Fairfield	8.2	9.3	8.2	8.7	34.4
Farmington	11.1	11.1	10.7	10.6	43.5
Flagstaff	8.3	11.1	9.0	8.3	36.7
Gardiner	10.74	9.83	10.52	11.27	42.36
Greenville	10.6	13.0	11.8	10.1	45.5
Houlton	6.2	7.7	8.1	7.1	29.1
Jackman	9.4	12.1	8.6	8.2	38.3
Kineo	7.9	11.4	7.4	7.3	34.0
Lewiston	11.15	10.19	10.44	11.69	43.47
Livermore	10.7	11.3	11.2	9.8	43.0
Madison	11.6	12.2	11.4	10.9	46.1
Mayfield	10.8	13.6	11.9	10.4	46.7
Middle Dam	7.9	12.0	8.9	6.3	35.1
Millinocket	9.9	11.6	11.8	10.7	44.0
Milo	9.6	11.2	11.7	6.9	39.4
N. Bridgton	11.2	11.8	10.7	11.2	44.9
Old Town	10.3	11.0	11.1	9.9	42.3
Oquossoc	9.2	11.3	9.0	9.4	38.9
Orono	9.87	10.05	10.45	10.87	41.24
Patten	8.5	11.3	11.7	8.8	40.3
Portland	10.97	9.70	9.71	11.95	42.33
Presque Isle	8.1	8.9	8.8	10.4	36.2
Rumford Falls	10.0	11.3	10.3	9.5	41.1
Songo	10.7	10.8	10.1	10.9	42.5
The Forks	9.3	13.2	10.0	8.1	40.6
Upper Dam	7.64	9.95	8.26	6.93	32.78
Van Buren	8.0	11.8	9.2	7.9	36.9
Winslow	9.4	10.3	9 9	8.9	38.5
Woodland	11.2	8.7	13.1	10.6	43.6
Wytopitlock	9.2	11.0	11.6	8.5	40.3

*Editor's Note: Previously printed in this JOURNAL, Vol. XLIII, No. 1, March, 1929, pp. 50–55.
†Mining Geologist, Detroit, Mich.

New Hampshire.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Alstead	9.1	11.7	10.5	8.7	40.0
Belmont	8.9	10.3	9.6	11.2	40.0
Berlin	8.4	11.2	9.2	8.2	37.0
Berlin Mills	8.7	10.6	9.2	9.1	37.6
Bethlehem	8.5	12.2	10.2	7.5	38.4
Bristol	10.3	10.8	10.0	10.4	41.5
Brookline	10.9	10.8	10.5	10.2	42.4
Concord	8.96	10.20	9.17	9.03	37.36
Durham	9.7	9.9	10.3	10.5	40.4
Errol	8.27	11.49	9.45	8.28	37.49
Fitzwilliam	10.7	13.1	11.3	10.3	45.4
Franklin	10.0	11.6	10.5	10.0	42.1
Glencliff	10.2	12.1	11.1	9.5	42.9
Gorham	8.5	9.7	9.0	7.4	34.6
Grafton	9.0	10.7	9.3	9.3	38.3
Hanover	8.42	10.23	8.83	7.43	34.91
Keene	8.9	10.9	9.5	8.9	38.2
Lakeport	10.34	10.58	10.05	11.17	42.14
Littleton	8.3	11.4	10.0	9.1	38.8
Manchester	9.92	9.83	9.50	9.96	39.21
Mt. Washington	18.03	28.04	22.49	13.65	82.21
Nashua	9.83	9.84	9.26	10.40	39.33
Newton	10.0	9.8	10.2	10.0	40.0
North Conway	9.9	9.9	9.5	11.9	41.2
Peterboro	9.3	11.0	10.0	10.1	40.4
Pittsburg (a)	8.6	11.9	11.6	8.7	40.8
Pittsburg (b)	9.7	13.3	12.2	9.8	45.0
Plymouth	9.41	11.09	10.19	9.60	40.29
Profile	....	....	....	....	50.9
Sanbornton	8.8	11.2	9.9	7.8	37.7
Stratford	7.6	12.2	9.7	7.1	36.6
Weirs	9.7	10.8	9.4	10.6	40.5
West Milan	8.1	11.6	9.7	10.6	40.0
West Stewartstown	5.8	10.9	8.6	5.9	31.2
Wolfeboro	10.2	10.3	9.7	11.7	41.9
Woodstock	10.6	14.6	12.2	10.6	48.0
Woodville	7.7	10.4	8.6	8.2	34.9

Vermont.

	Spring.	Summer.	Autumn.	Winter.	Annual.
Bellows Falls	8.5	9.6	8.9	8.0	35.0
Bennington	8.8	12.5	10.1	9.4	40.8
Bloomfield	8.0	12.5	9.9	6.5	36.9
Brattleboro	9.7	10.1	10.2	10.9	40.9
Burlington	7.22	10.45	8.96	5.15	31.78
Cavendish	9.1	10.8	9.7	8.8	38.4
Chelsea	8.51	10.21	8.97	7.88	35.57
Cornwall	6.7	10.0	8.4	6.1	31.2
Enosburg Falls	8.7	12.6	10.5	7.6	39.4
Fitzdale	6.4	11.1	7.7	5.1	30.3
Garfield	8.6	12.5	10.0	9.0	40.1
Guildhall	6.7	12.4	8.2	5.1	32.4
Halifax	9.6	10.3	10.0	11.0	40.9
Hyde Park	8.1	12.8	10.8	7.2	38.9
Jacksonville	10.7	10.6	11.3	11.8	44.4
Londonderry	9.0	10.0	8.7	8.4	36.1
Manchester	9.7	10.9	11.3	9.2	41.1
Morrisville	....	....	....	....	....
Northfield	7.69	10.10	8.35	6.80	32.94
Norwich	8.7	10.5	9.3	8.7	37.2
Readsboro	11.7	14.0	11.5	10.8	48.0
Ryegate	7.9	11.3	7.9	6.5	33.6
St. Johnsbury	7.96	11.11	9.11	6.69	34.87
Somerset	11.8	13.7	13.4	13.6	52.5
Strafford	9.0	11.4	9.5	9.0	38.9
Vernon	9.8	10.7	10.6	9.1	40.2
Victory	7.9	14.1	10.2	5.8	38.0
Wells	8.9	11.2	9.7	8.7	38.5
West Hartland	9.8	11.1	10.0	8.7	39.6
West Rutland	8.1	9.5	8.7	7.1	33.4
White River Jct.	8.1	9.0	8.8	7.4	33.3
Wilmington	10.6	13.2	11.3	12.3	47.4
Woodstock	9.41	10.58	9.50	8.63	38.12

Mean Monthly Rainfall.
Adjusted to 1881–1925.

Maine.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Ashland	1.9	3.2	2.5	2.1	2.9	3.6	3.1	3.4	2.6	4.5	2.5	2.5	34.8
Azischos Dam	2.6	1.9	2.8	2.4	3.3	3.9	3.9	4.3	3.8	2.8	2.9	2.2	36.8
Bar Harbor	4.8	4.2	5.2	3.6	3.8	3.2	3.6	3.4	3.8	4.2	4.6	4.6	49.0
Belfast	4.7	4.3	4.5	2.8	3.1	3.4	3.6	3.2	3.5	3.5	3.9	4.6	45.1
Calais	4.7	4.3	4.7	3.5	3.5	3.2	3.6	3.7	3.3	4.4	4.2	4.6	47.7
Camden	3.0	2.4	3.8	3.4	3.8	3.0	3.2	3.1	4.2	4.6	4.1	3.8	42.4
Cornish	3.77	3.98	4.25	3.60	3.80	3.88	4.17	4.14	3.84	3.66	3.96	3.81	46.86
Danforth	3.8	3.7	3.3	2.9	2.7	3.3	3.5	3.0	3.1	3.4	4.2	3.1	40.0
Eastport	3.91	3.38	3.83	2.81	3.06	2.91	2.97	2.94	2.70	3.43	3.26	3.74	38.94
Fairfield	2.9	2.8	3.0	2.4	2.8	2.7	3.4	3.2	2.9	2.7	2.6	3.0	34.4
Farmington	3.5	3.4	4.0	3.3	3.8	3.8	3.6	3.7	3.8	3.5	3.4	3.7	43.5
Flagstaff	2.9	2.6	3.0	2.5	2.8	4.0	3.6	3.5	3.1	2.9	3.0	2.8	36.7
Gardiner	3.92	3.64	4.10	3.27	3.37	3.23	3.50	3.10	3.52	3.59	3.41	3.71	42.36
Greenville	3.2	3.2	3.80	3.0	3.8	4.1	4.7	4.2	4.2	3.5	4.1	3.7	45.5
Houlton	2.4	2.4	2.5	1.8	1.9	2.7	2.4	2.6	2.6	3.2	2.3	2.3	29.1
Jackman	2.6	2.9	3.0	2.3	4.1	4.7	4.4	3.0	2.4	2.8	3.4	2.7	38.3
Kineo	2.0	1.9	2.4	3.1	2.4	3.7	4.6	3.1	2.1	2.1	3.2	3.4	34.0
Lewiston	3.95	3.82	4.17	3.39	3.59	3.44	3.72	3.03	3.54	3.39	3.51	3.92	43.47
Livermore	3.4	3.2	4.0	3.3	3.4	3.5	3.3	4.5	3.8	3.7	3.7	3.2	43.0
Madison	3.8	3.5	3.9	3.6	4.1	4.2	3.8	4.2	4.0	3.7	3.7	3.6	46.1
Mayfield	3.5	3.3	3.7	3.3	3.8	4.3	5.0	4.3	3.8	3.9	4.2	3.6	46.7
Middle Dam	2.4	1.8	2.5	2.1	3.3	3.9	4.0	4.1	3.6	2.6	2.7	2.1	35.1
Millinocket	3.6	3.4	3.7	3.0	3.2	3.8	3.7	4.1	3.7	3.6	4.5	3.7	44.0
Milo	2.6	2.5	3.0	2.0	4.6	3.9	3.4	3.9	3.3	3.8	4.6	1.8	39.4
N. Bridgton	3.7	3.8	4.0	3.4	3.8	3.7	4.3	3.8	3.8	3.3	3.6	3.7	44.9
Old Town	3.0	3.2	3.6	3.1	3.6	3.4	3.5	4.1	3.6	3.5	4.0	3.7	42.3
Oquossoc	3.2	3.2	3.5	2.3	3.4	3.5	4.3	3.5	3.9	2.4	2.7	3.0	38.9
Orono	3.92	3.47	3.67	2.90	3.30	3.39	3.43	3.23	3.54	3.34	3.57	3.48	41.24
Patten	3.0	3.0	2.8	2.3	3.4	4.1	3.8	3.4	4.1	3.9	3.7	2.8	40.3
Portland	3.98	4.00	4.01	3.41	3.55	3.26	3.30	3.14	3.21	3.11	3.39	3.97	42.33
Presque Isle	3.0	3.9	2.7	2.4	3.0	3.2	2.7	3.0	2.9	3.3	2.6	3.5	36.2
Rumford Falls	3.1	3.3	3.3	3.0	3.7	3.7	3.8	3.8	3.7	3.2	3.4	3.1	41.1
Songo	3.8	3.6	3.6	3.4	3.7	3.3	3.8	3.7	3.0	3.9	3.2	3.5	42.5
The Forks	2.6	2.9	2.7	2.8	3.8	4.3	5.5	3.4	3.4	3.0	3.6	2.6	40.6
Upper Dam	2.48	2.07	2.58	2.19	2.87	3.32	3.33	3.30	3.14	2.45	2.67	2.38	32.78
Van Buren	2.6	2.6	2.8	1.9	3.3	4.1	3.7	4.0	3.0	3.8	2.4	2.7	36.9
Winslow	3.1	2.8	3.4	2.8	3.2	3.1	3.8	3.4	3.5	3.4	3.0	3.0	38.5
Woodland	3.7	2.7	3.7	4.0	3.5	3.6	2.1	3.0	4.1	4.7	4.3	4.2	43.6
Wytopitlock	3.1	2.6	3.2	2.6	3.4	4.2	2.8	4.0	4.1	3.7	3.8	2.8	40.3

New Hampshire.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Alstead	2.9	2.8	3.1	2.8	3.2	3.6	4.1	4.0	3.8	3.0	3.7	3.0	40.0
Belmont	3.8	3.6	3.8	2.2	2.9	3.1	3.5	3.7	3.3	2.9	3.4	3.8	40.0
Berlin	2.8	2.6	3.2	2.6	2.6	3.9	3.7	3.6	3.4	2.8	3.0	2.8	37.0
Berlin Mills	3.1	3.0	3.3	2.6	2.8	3.6	3.3	3.7	3.3	2.8	3.1	3.0	37.6
Bethlehem	2.5	2.4	2.9	2.5	3.1	4.0	4.2	4.0	3.8	3.1	3.3	2.6	38.4
Bristol	3.6	3.1	3.5	3.7	3.1	3.7	3.6	3.5	2.9	3.3	3.8	3.7	41.5
Brookline	3.4	3.4	3.9	3.5	3.5	3.4	3.6	3.8	3.7	3.4	3.4	3.4	42.4
Concord	3.03	2.89	3.14	2.74	3.08	3.19	3.49	3.52	3.46	2.79	2.92	3.11	37.36
Durham	3.7	3.3	3.1	3.1	3.5	3.5	3.2	3.2	3.8	3.4	3.1	3.5	40.4
Errol	2.78	2.65	2.88	2.58	2.81	3.80	3.72	3.97	3.42	3.01	3.02	2.85	37.49
Fitzwilliam	3.3	3.7	3.5	3.8	3.4	4.2	4.2	4.7	3.8	3.5	4.0	3.3	45.4
Franklin	3.4	3.4	3.6	3.1	3.3	4.0	3.8	3.8	3.9	3.3	3.3	3.2	42.1
Glencliff	3.1	3.1	3.3	3.3	3.6	3.7	4.1	4.3	4.0	3.6	3.5	3.3	42.9
Gorham	2.3	2.4	3.0	2.7	2.8	3.4	3.0	3.3	3.1	2.6	3.3	2.7	34.6
Grafton	3.2	3.2	3.1	2.5	3.4	3.0	4.1	3.6	3.3	3.0	3.0	2.9	38.3
Hanover	2.50	2.45	2.79	2.44	3.19	3.39	3.50	3.34	3.38	2.66	2.79	2.48	34.91
Keene	3.0	2.8	3.1	2.7	3.1	3.0	3.8	4.1	3.7	2.9	2.9	3.1	38.2
Lakeport	3.69	3.78	4.03	3.14	3.17	3.37	3.76	3.45	3.59	2.98	3.48	3.70	42.14
Littleton	2.9	3.2	2.9	2.2	3.2	3.9	3.7	3.8	3.2	3.1	3.7	3.0	38.8
Manchester	3.36	3.23	3.65	3.01	3.26	2.99	3.52	3.32	3.38	2.91	3.21	3.37	39.21
Mt. Washington	4.27	4.16	5.92	5.94	6.17	9.08	10.34	8.62	8.42	7.45	6.62	5.22	82.21
Nashua	3.49	3.53	3.72	3.09	3.02	2.97	3.42	3.45	3.19	2.93	3.14	3.38	39.33
Newton	3.6	3.3	3.3	3.3	3.4	3.3	3.3	3.2	3.4	3.4	3.4	3.1	40.0
North Conway	3.8	3.7	3.5	3.1	3.3	3.2	3.7	3.0	3.0	3.2	3.3	4.4	41.2
Peterboro	3.4	3.3	3.4	3.0	2.9	3.7	3.4	3.9	3.8	3.0	3.2	3.4	40.4
Pittsburg (a)	3.0	2.5	3.1	2.5	3.0	4.6	3.4	3.9	4.8	3.6	3.2	3.2	40.8
Pittsburg (b)	3.1	3.1	3.4	2.6	3.7	5.5	3.9	3.9	5.2	3.8	3.2	3.6	45.0
Plymouth	3.23	3.07	3.38	2.81	3.22	3.64	3.77	3.68	3.72	3.19	3.28	3.30	40.29
Profile	...	...	...	...	...	...	....	....	....	....	....	....	50.9
Sanbornton	2.7	2.4	3.0	2.5	3.3	3.4	4.3	3.5	3.9	2.9	3.1	2.7	37.7
Stratford	2.4	2.0	2.5	2.1	3.0	3.9	4.4	3.9	3.7	3.1	2.9	2.7	36.6
Weirs	3.5	3.5	3.5	3.0	3.2	3.8	3.7	3.3	3.6	2.7	3.1	3.6	40.5
West Milan	3.8	3.4	2.9	2.4	2.8	4.0	3.9	3.7	3.5	2.9	3.3	3.4	40.0
W. Stewartstown	2.2	2.0	2.1	1.7	2.0	3.7	3.6	3.6	3.6	2.9	2.1	1.7	31.2
Wolfeboro	4.2	3.8	3.7	3.3	3.2	3.4	3.9	3.0	3.5	2.9	3.3	3.7	41.9
Woodstock	3.4	3.5	3.9	2.8	3.9	4.0	5.0	5.6	4.7	4.0	3.5	3.7	48.0
Woodville	2.6	2.8	3.0	1.9	2.8	3.8	3.7	2.9	3.2	2.9	2.5	2.8	34.9

Vermont.

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	An.
Bellows Falls	2.6	2.7	2.9	2.2	3.4	2.9	3.4	3.3	2.9	2.5	3.5	2.7	35.0
Bennington	2.6	4.0	2.9	2.2	3.7	4.3	4.5	3.7	4.0	3.1	3.0	2.8	40.8
Bloomfield	2.2	2.0	2.5	2.5	3.0	3.8	4.6	4.1	4.0	3.1	2.8	2.3	36.9
Brattleboro	3.8	3.5	3.6	3.0	3.1	2.9	3.1	4.1	3.3	3.5	3.4	3.6	40.9
Burlington	1.67	1.63	2.11	2.18	2.93	3.60	3.46	3.39	3.64	2.84	2.48	1.85	31.78
Cavendish	3.1	2.7	2.9	2.7	3.5	3.2	4.1	3.5	3.5	3.0	3.2	3.0	38.4
Chelsea	2.70	2.63	2.98	2.55	2.98	3.32	3.33	3.56	3.40	2.67	2.90	2.55	35.57
Cornwall	2.0	2.0	2.0	2.0	2.7	3.4	3.4	3.2	3.2	2.7	2.5	2.1	31.2
Enosburg Falls	2.5	2.4	2.7	2.6	3.4	4.4	4.4	3.8	4.0	3.6	2.9	2.7	39.4
Fitzdale	1.6	1.4	1.9	1.9	2.6	3.8	4.0	3.3	2.8	2.6	2.3	2.1	30.3
Garfield	3.4	2.5	2.6	2.5	3.5	3.6	3.9	5.0	3.7	3.5	2.8	3.1	40.1
Guildhall	1.8	1.7	2.0	1.9	2.8	3.5	4.5	4.4	3.4	2.7	2.1	1.6	32.4
Halifax	3.9	3.5	3.2	2.8	3.6	3.1	3.5	3.7	3.5	3.0	3.5	3.6	40.9
Hyde Park	2.4	2.2	2.4	2.7	3.0	4.1	5.0	3.7	4.7	3.0	3.1	2.6	38.9
Jacksonville	4.0	4.3	3.7	3.5	3.5	3.2	3.8	3.6	4.2	3.6	3.5	3.5	44.4
Londonderry	2.8	2.8	2.8	3.1	3.1	3.2	3.6	3.2	2.7	3.1	2.9	2.8	36.1
Manchester	3.1	3.1	2.9	2.6	4.2	3.1	3.6	4.2	4.8	3.4	3.1	3.0	41.1
Morrisville	...	...	...	...	...	...	...	...	...	...	...	...	...
Northfield	2.26	2.21	2.62	2.32	2.75	3.22	3.46	3.42	3.06	2.69	2.60	2.33	32.94
Norwich	3.1	2.7	2.9	2.5	3.3	3.4	3.6	3.5	3.5	2.8	3.0	2.9	37.2
Readsboro	3.6	3.2	3.3	3.7	4.7	4.9	4.3	4.8	3.6	4.1	3.8	4.0	48.0
Ryegate	2.0	2.2	2.8	2.4	2.7	3.1	4.4	3.8	3.0	2.5	2.4	2.3	33.6
St. Johnsbury	2.15	2.16	2.63	2.51	2.82	3.39	3.86	3.86	3.72	2.77	2.62	2.38	34.87
Somerset	4.8	4.4	3.8	3.6	4.4	4.3	4.7	4.7	3.9	5.0	4.5	4.4	52.5
Strafford	3.0	2.9	3.3	2.3	3.4	3.7	3.8	3.9	3.3	3.0	3.2	3.1	38.9
Vernon	3.3	2.6	3.5	3.1	3.2	3.1	3.6	4.0	4.1	3.4	3.1	3.2	40.2
Victory	1.7	2.2	2.2	2.4	3.3	4.7	5.1	4.3	4.5	3.2	2.5	1.9	38.0
Wells	2.8	3.2	3.3	2.4	3.2	3.2	4.0	4.0	4.0	2.9	2.8	2.7	38.5
West Hartland	2.6	2.8	3.1	3.0	3.7	3.5	4.0	3.6	3.6	3.1	3.3	3.3	39.6
West Rutland	2.5	2.2	2.5	2.3	3.3	3.2	3.1	3.2	3.2	2.7	2.8	2.4	33.4
White River Jct.	2.6	2.3	2.9	2.2	3.0	3.0	3.1	2.9	2.9	2.5	3.4	2.5	33.3
Wilmington	3.9	3.9	3.4	2.7	4.5	4.8	3.9	4.5	3.6	4.1	3.6	4.5	47.4
Woodstock	2.91	2.84	3.18	2.75	3.48	3.31	3.78	3.49	3.57	2.81	3.12	2.88	38.12

THE WEATHER-MAP STORY OF THE FLOODING RAINSTORM OF NEW ENGLAND AND ADJOINING REGIONS, NOVEMBER 3–4, 1927.*

BY J. HENRY WEBER† AND CHARLES F. BROOKS.†

[*Read January 11, 1928.*]

Three factors joined to make the extraordinary rainstorm in New England, November 3–4, 1927 — according to a weather-map study. The first factor was a large supply of damp tropical air that happened to be on tap over the Gulf Stream and the Atlantic southward. It was marked by low pressure on the weather maps for a few days preceding the flood. The second factor was the piling-up of a great and almost immovable mass of air in the East, from Maine, Nova Scotia and Newfoundland eastward. This was marked by high pressure on the maps. The third factor was the southward flow of a considerable body of cold air into northern New England and along the Appalachian ranges and through their valleys to the Middle Atlantic coast. After three days of northward flow of the tropical air, funneled into western New England between the air masses on the east and on the west, such great masses of damp air were forced together and up over the obstructing mountains and their northern and western higher bulwarks of cold air — while at the same time they were being overturned by the cold air above — that unprecedented quantities of water fell in a short time.

The rainfall in southern New England and New York east of the Hudson River averaged about five inches, and locally amounted to over nine inches. Vermont's downpour averaged not less than seven inches for the entire State. The average fall in New Hampshire was about five inches and that in Maine three inches or slightly less, ranging from under an inch on the coast at Portland to over four inches to the northwest. The heaviest rains occurred along the length of the Green Mountains, where the mountain wall and the cold air to the west forced the greatest ascent of the warm air; and in a belt from Westerly, R. I., to Groton, Mass., the path of a small low-pressure center within the general storm. The main storm center moved northward up the Connecticut Valley and was attended by high southerly and southeasterly winds and gales on its east side. The development and movement of this storm was clearly shown by the four-hourly weather maps constructed from data received from U. S. Weather Bureau and Canadian weather service stations, also from ships at sea.

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How the Stage Was Set.

The tropical contribution to the New England flood began early in October, during which month three heavy rainstorms, largely of tropical origin, soaked New England. A week before the flood the barometer was relatively low in the middle and eastern Caribbean, and on the evening of October 28 a disturbance of slight intensity passed over Santa Lucia, in the Windward Islands, advancing apparently west or northwestward. Havana reported nearly 12 in. (11.86) of rainfall for the 24-hour period ending at 8 A.M. on the 29th. On the 30th and 31st the barometer continued low south and southeast of Cuba. On November 1 the barometer was low over southern Florida, Cuba and the Bahamas, with the lowest pressure, 29.78 in., over central Cuba. The morning of the 2nd a tropical low-pressure area, apparently of slight intensity, was noted just east of the Bahamas, moving north-northwestward. Other meteorological conditions were extremely favorable for the northward movement of great masses of tropical air and, in consequence, for the further development of this general tropical low-pressure area and its expansion over the eastern seaboard.

During the last few days of October the pressure distribution on the continent of North America favored strong southerly winds in the Middle West. In consequence, great volumes of warm, moist air were transported from the Gulf of Mexico far northward into Canada. The Atlantic coast and the Appalachian region, however, experienced clear and moderately cool weather with northerly winds, attending the southeastward advance of an area of higher pressure from Canada. It was this high that later formed the central and southern portion of the air wall over the western Atlantic that helped drive northward the enormous flow of tropical air that passed over New England early in November.

By October 31, there was a temporary reaction to colder weather in the lower Missouri and the upper Mississippi valleys, but the temperatures continued unseasonably warm in most of the Lake region and in the Ohio Valley, while the remainder of the eastern United States showed a reëstablishment of seasonal or abnormal warmth. Some stations in the Ohio Valley and the Lake region reported temperatures equalling or exceeding the record for so late in the season, some readings being as high as 80° F. The warm weather overspread the Atlantic States by November 1. Over the East the movement of air from a tropical quarter continued unabated through the 2nd. An area of lower barometer in the Mississippi Valley moved rapidly northeastward. On the morning of the 2nd a sharp trough of low pressure, marked by nocturnal thunderstorms, extended from its center, southeast of Hudson Bay, south and southwestward to Texas. This marked the dividing line between the considerably cooler temperatures on the west and the abnormal warmth on the east. Boston, with a maximum of 76° F., had the temperature equal to the highest for November ever recorded in the history of the local station. This low-pressure area

was a secondary of the Pacific low that appeared in the western Aleutian Islands October 19 and entered North America, October 28. The primary center was at this time over Baffin Bay. This energetic secondary moved northward to the mouth of Hudson Bay.

Moderately heavy rains occurred in northern New York and Vermont during the night of November 2nd as the cold front of the storm area passed northeastward between Hudson Bay and the St. Lawrence River. The temperature began to fall incident to its passage and by 8 P.M. the 2nd the readings were in the forties, or below, west of a line northeastward from Tennessee through the Ohio Valley and western New York to Montreal. On the east, far north, to the mouth of the St. Lawrence River, the temperatures of the southerly winds were in the neighborhood of 60° F. or higher. The barometer had fallen along the Atlantic coast, due to the eastward movement of a mass of air of lighter density in connection with the northern storm and, subsequently, owing to the great inflow of tropical air from the ocean.

The Weather-Map Story in Detail.

During the following twelve hours the tropical low-pressure area and the southern end of the trough from the northern low increased considerably in extent and exerted their influence over the entire Atlantic coastal region. In order to obtain a comprehensive understanding of its movement, intensity, and the meteorological conditions in the area influenced by this storm, special maps have been constructed. (Figs. 1–6.) These maps show the weather conditions beginning at 8 A.M. on the 3rd and ending at 8 P.M. the 4th. Reports of weather conditions were obtained with the cordial assistance of the Boston office of the U. S. Weather Bureau, Mr. G. A. Loveland, official in charge, for all United States stations and for many Canadian stations east of the 80th meridian, as well as ship reports from the western Atlantic Ocean. Special reports for this period were also received from private observatories at Amherst and Worcester, Mass., and from Brattleboro, Vt.

Figure 1 shows that at 8 A.M. November 3 the barometer readings were about 29.6 in. in the Carolinas and eastern Virginia, with low pressures extending far out to sea; while another low center, the tropical disturbance, was now apparently near latitude 30 north and longitude 74 degrees west.

The cold, dense air had made little progress eastward, except in the northern portion of the St. Lawrence Valley. The Appalachian Mountains marked, in general, the boundary line between the cooler, drier air to the westward and the very warm, humid air to the eastward. In New England the cold air had advanced to the crest of the Green Mountains and the Berkshire Hills, the east-west gradient in temperature being unusually steep. At Albany at 8 A.M. the thermometer read 44° F., while at Amherst, Mass., it stood at 63° F. — a difference of 19° in 70 miles. At Concord,

N. H., and at Brattleboro, Vt., the temperature was 60° F., while at Northfield, Vt., the mercury was 42° — a difference of 18° in 80 miles.

With an immense wall of dense air to the northeastward, where the barometer reading was as high as 30.4 in. at Cape Race, Newfoundland, and above 30.6 in. over the ocean to the east, and a cold wall of air to the

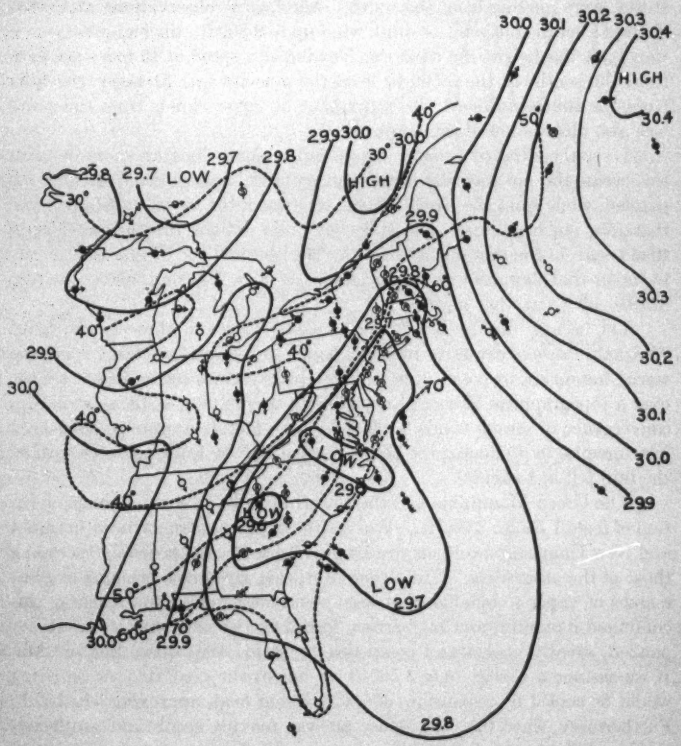

FIG. 1.— NOVEMBER 3, 1927.— 8 A.M.

west and northwestward, the south Atlantic storm area was as if caught in a vise by its meteorological enemies. The path of least resistance was northward along the coast and thence inland into New England. The pressure distribution already indicated this, for there was a narrow pointer of lower pressure extending northward to southern Vermont, while there was a looping of the isobars from there north-northeastward to the St. Lawrence River, indicating perhaps a greater northward movement of the tropical air there than elsewhere on the east or west.

The great, moisture-bearing tropical current was of considerable depth, as is indicated not only by the northward movement of the low-pressure area but also by cloud drifts. For example, observations at Worcester, Mass., showed an inflow of air from the southeast or south to a height of at least two miles, where alto-cumulus clouds, the highest visible during the storm, were moving from the south. Aërological observations at Boston showed a south-southeast or south wind up to 9 800 ft., the highest observation. At this height the wind was blowing at a speed of 45 miles per hour from the south; at the 6 500-ft. level the velocity was 51 miles per hour from the south-southeast. A movement of upper clouds from the south was also observed at Washington, D. C.

Over the Atlantic coastal region and to some distance eastward over the ocean the air was warm and muggy and, consequently, greatly expanded, while from the Appalachians westward, the air was cold, dry, and therefore much denser. The stage was now set for the torrential rains that began in the district between the Hudson and the Connecticut rivers by noon that day, and in the remainder of New England, except eastern Maine, by 8 P.M. that night.

Let us now discuss briefly the physical causes of these heavy rains. The main cause of excessive precipitation is the elevation of large masses of warm, humid air, by convection or instability overturning, by forced ascent, over a topographical barrier or even over a barrier of cold, dense air, or by convergence of strong winds. All the above factors appear to have been instrumental in producing the heavy rainfall in New England. No wonder the rain fell in torrents!

The Green Mountains and the Berkshire Hills have an average elevation of from 1 500 to 3 000 ft. West of these, and across northern Vermont and New Hampshire, cold air was banked up to heights probably exceeding those of the mountains. The strong southeasterly winds, bringing in great masses of vapor to heights of at least two miles, were, upon reaching this combined mountain and air barrier, forced to rise and were therefore expanded, greatly cooled and compelled to yield large quantities of rain. If we assume a barrier only 3 500 ft. in height the saturated air on rising would be cooled by expansion, offset by latent heat, approximately 10° F. Furthermore, since the cold, dense air was moving south and southeastward and the warm, light air northwestward, there was a convergence of these air masses, violent upthrusts, with instability overturning above, and additional cooling; all these factors producing an aggregate cooling of at least 15 to 20° F. Saturated air when cooled 18° F. has its so-called capacity for holding moisture reduced by about one-half. Since, very likely, the cooling in this case was approximately equal to or greater than that amount, we can easily see why the rain fell in torrents along and to some distance east and west of the line of greatest upthrust of the warm, muggy air. As the meteorological conditions, mentioned previously, did not change materially during the subsequent 24 hours, it is not difficult to

conceive of the recorded 6 to nearly 10 in. of rain falling in the Berkshire Hills, the Green Mountains, and in the adjoining regions. More than a cubic mile of water fell on the State of Vermont. For the precipitation of such a vast quantity of rain a mass of warm, damp air, equivalent to a current

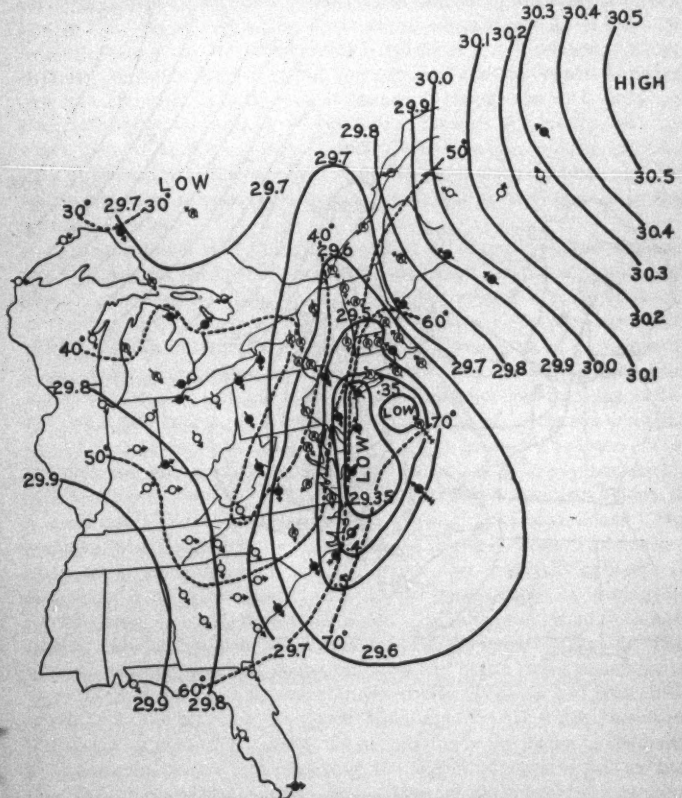

FIG. 2.— NOVEMBER 3, 1927.— 8 P.M.

two miles deep and covering four or five times the area of Vermont, must have passed over the State and ascended two miles while doing so.

During the 12 hours following 8 A.M. of November 3 the tropical air continued its rapid flow northward, but there was little change in the position of the front of cold, dense air to the west and northeastward. At noon the barometer had fallen along the Atlantic seaboard from Florida

to Nova Scotia. The pressure readings were in the neighborhood of 29.55 in. from North Carolina to Long Island, with one center of slightly lower pressure over central Virginia and North Carolina, a second off the coast of Virginia, and a third, the tropical low (not shown on the maps) farther

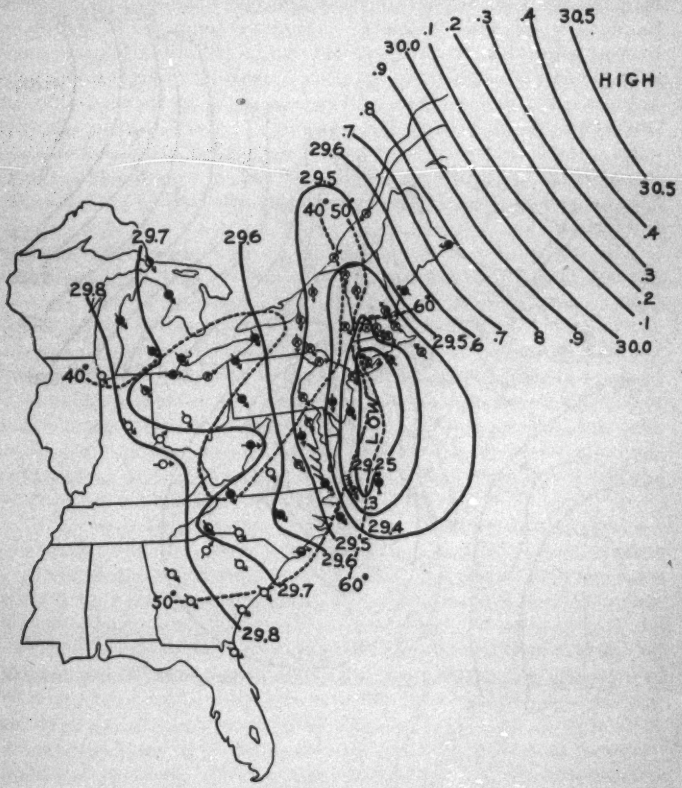

FIG. 3.— NOVEMBER 3, 1927.— 12 P.M.

out to sea. Ships to the east and southeast of the center near the coast reported southeast winds of force 6 to 9.

By 4 P.M. the two coastal centers noted at noon had apparently combined into one well-defined storm area. It now appeared as an oblong low, extending from North Carolina to Long Island, Atlantic City reporting the lowest pressure, 29.38 in. The 8 P.M. map (Fig. 2) shows that the center of the low was along the coast of New Jersey, Atlantic City and New York,

both having a barometer reading of 29.33 in., while a few ship reports indicate a second low of similar intensity, possibly the tropical low, south of New England. This map, like the three previous ones, shows a conspicuous wedge of lighter air, or lower pressure, extending from the southern New England coast to the central portion of Vermont and New Hampshire. By midnight (Fig. 3) the storm center was south of the New England coast where the pressure was below 29.25 in. The narrow wedge of lighter air still extended up the Connecticut Valley to central Vermont and New Hampshire; to the west it seemed as though the cold, dense air were attempting to push its way eastward through this wedge, but the warm tropical air with inexhaustible reserves speeding rapidly in from the southeastward repulsed the sallies of its meteorological foes. Twelve more hours were to pass before this territory was to be evacuated by the southern invader.

By midnight it is probable that the low, noted south of New England at 8 P.M., had moved inland from the Rhode Island coast, and at midnight it was centered between Providence, R. I., and Worcester, Mass. (not shown on the maps because of small scale). At Worcester the reduced barometer was 29.4 in., or .06 to .10 in. higher than at Providence, R. I., Concord, N. H., and Amherst, Mass., and .02 in. higher than at Boston. The wind at Providence was blowing at a velocity of 50 miles per hour from the southeast while at Worcester it was north 8 miles per hour. Between midnight and 1 A.M. the rain fell at a rate of nearly 2 in. per hour at Worcester. This low pressure, one of small diameter, was undoubtedly largely responsible for the excess of 3 to 5 in. that brought totals of from more than 9 down to 6 in. of rainfall from Westerly, R. I., northward to Groton, Mass. The greatest rainfall intensity in Vermont, and possibly western Massachusetts, occurred between 11 A.M. and 8 P.M., but especially between 11 A.M. and 5 P.M., November 3. Northfield reported 4.24 in. during the former period and 3.20 during the latter. In Burlington, conditions were similar, although the rate of fall was not as great as at Northfield. This heavy rainfall occurred before general rains had begun in the remainder of New England, for then the warm, moist southerly winds had been dried but little before reaching the Green Mountains. After 8 P.M., however, the humid air gave up an abundance of moisture in the region to the south and southeast, so that upon reaching the Green Mountains this air had already been considerably dried. In consequence, the rate of fall in western Massachusetts and Vermont could not be so excessive as during the previous period, although the rate could still be classified as heavy.

Figure 4 shows that by 4 A.M., November 4, the center of the disturbance had moved inland into the Connecticut Valley, although the barometer was still falling. The lowest barometer readings were 29.08 in. at Amherst, Mass., and 29.09 at Hartford, Conn. The small disturbance over central Massachusetts had now apparently merged with the main storm. A slight northern disturbance, noticed north of Lake Superior at

8 A.M. of the 3rd, had moved farther eastward. This low-pressure area had practically joined the storm from the south by midnight, November 3, though showing as a separate center to the north at 4 A.M. the 4th, Montreal having a barometer reading of 29.26 in., lower than any of the near-by

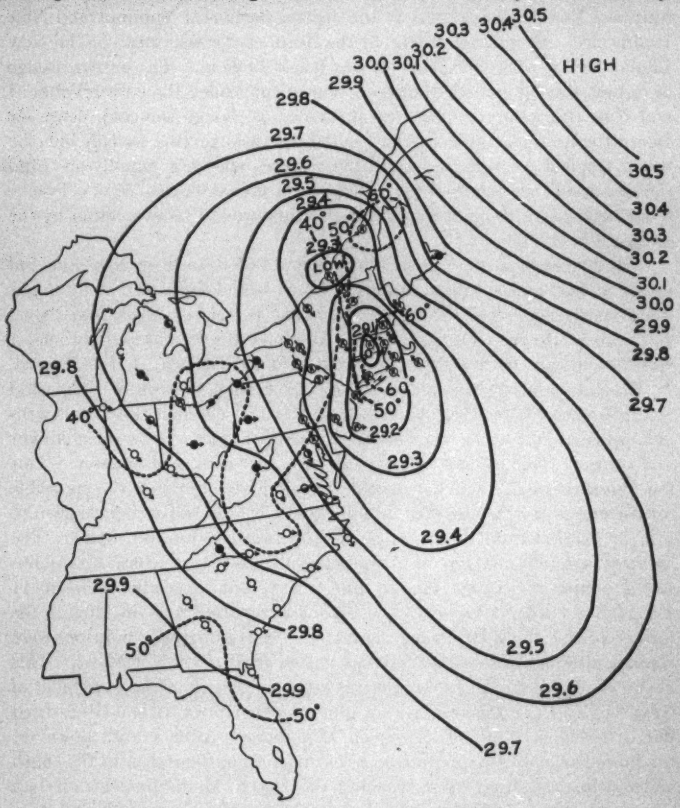

FIG. 4.— NOVEMBER 4, 1927.— 4 A.M.

weather stations. It is interesting to note that although Quebec, Que., had a strong northeast wind, the temperature rose from 42° F. at 8 P.M. to 56° at midnight, and to 62° at 4 A.M., November 4. This warmth continued to the late afternoon of that day and was due to the warm air traveling from the southeastward, some passing down and over the mountains, where much latent heat was given up, and then in a curved path from the northeast up the St. Lawrence Valley. At Northfield there was a somewhat

similar rise, from a temperature of 44° F. at midnight to 59° at 3 A.M., but this warmth was short-lived, for soon after 4 A.M. the cold air again held sway at the surface, the mercury tumbling to 46° at 8 A.M.

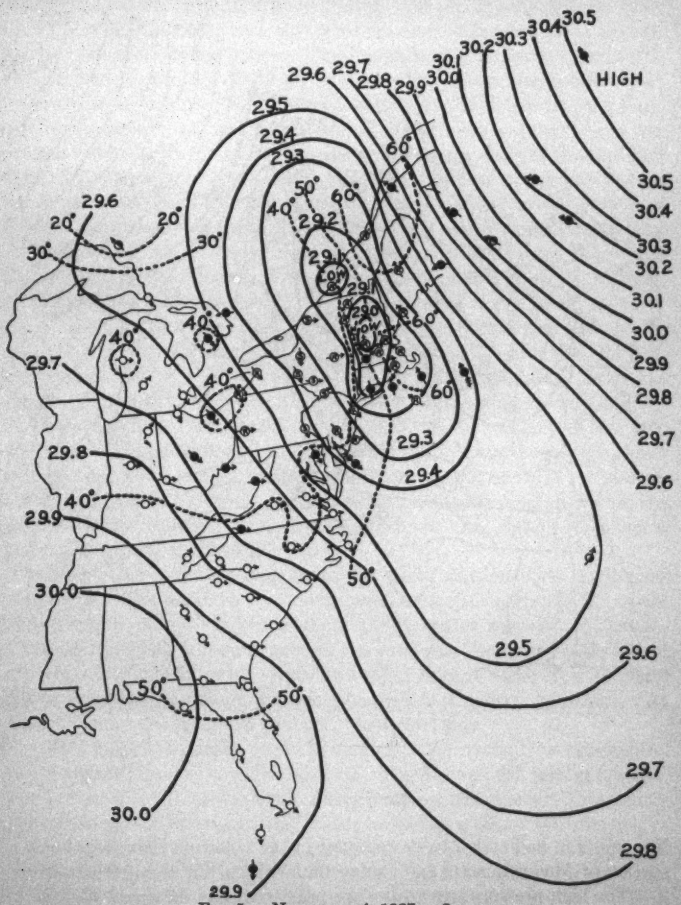

FIG. 5.— NOVEMBER 4, 1927.— 8 A.M.

Figure 5 indicates that at 8 A.M. the two storm centers were still present, as at 4 A.M., but both had increased in intensity. The southern center had moved up the Connecticut Valley to southern Vermont and New Hampshire, Brattleboro, Vt., reporting an unusually low barometer reading

of 28.97 in. (reduced to sea level). The northern center moved but little and the pressure had fallen to 29.08 in. at Montreal. The cold air that had advanced to the Atlantic Ocean south of New York City by midnight,

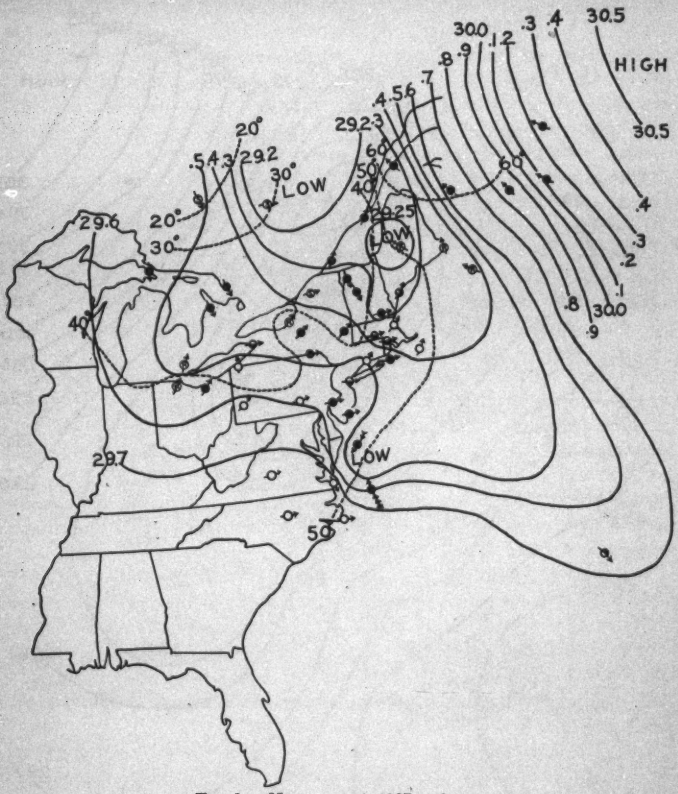

FIG. 6.— NOVEMBER 4, 1927.— 8 P.M.

November 3, had added to its conquest in the following eight hours only a portion of Massachusetts and Connecticut west of the Connecticut River.

The high-pressure area to the northeastward had remained stationary, with slightly increased strength compensating for the loss of air from New England. The two daily, northern hemisphere, weather maps made by Mr. W. P. Day, U. S. Weather Bureau, Washington, D. C., show that this Atlantic high was built in part from dense air relayed southwestward and southward from eastern, southern and southwestern Greenland by four

lows successively from October 29 to November 4. These lows first appeared on the maps, (1) in Central America October 15, with a companion over the Bahamas, October 17; (2) over Hudson Bay October 25; (3) over the Plateau region, western United States, October 25, an offshoot from a low; (4) in the Gulf of Alaska, that was first mapped October 19, approaching the western Aleutian Islands. This fourth low as it passed across North America had its primary center far in the north, with an energetic secondary crossing the continent in middle latitudes. It was this secondary that, as already mentioned, marked on the United States weather maps the western border of the great warm wave of the closing days of October and the first day or two of November. While its southern trough lingered on the Atlantic seaboard this low center moved northward to the mouth of Hudson Bay, then eastward, evidently crossing south central Greenland the night of the 3rd and bringing in its rear a considerable rise in pressure that appears to have increased the stagnant Atlantic high to its 30.72-in. maximum the evening of the 4th.

St. John's, Newfoundland, reported a barometer reading of 30.39 in. at 8 A.M., the 3rd, but by 8 P.M. it had risen to 30.53 and at 8 A.M., the 4th, the reading was 30.58 in. Sydney, Cape Breton Island, had a rising barometer during the 3rd but by 8 A.M., the 4th, the reading was the same as 24 hours previous. The barometer readings on the morning of the 4th, 300 miles east and southeast of Newfoundland, were in the neighborhood of 30.60 in., while farther to the eastward a reading of 30.72 in. was reported by the *S.S. Leviathan*. The pressure had, however, fallen over the Atlantic Ocean southeastward beyond Bermuda, this station reporting a barometer reading of 29.48 in.

During the following four hours the storm continued its northward movement. The southern center was northwest of Concord, N. H., where the barometer read 29 in., while the northern center was west of Quebec. The cold front had advanced around the southern center to Rhode Island and central Massachusetts. Rain was still falling in some New England districts but the amounts were inconsequential, except in Maine. At Eastport the rain did not set in until dusk that day.

By 4 P.M. the southern center had moved to northern New Hampshire, with decreased intensity, while the northern center was still west of Quebec. The last map of this series, 8 P.M. (Fig. 6), shows that the southern center was northwest of Greenville, Me., while the northern center was somewhere in the northwest portion of the Province of Quebec, Doucet having 29.18 in. (sea level pressure). A slight secondary was developing near the coast of New Jersey as the eastward advancement of the cold air over southern New England began to isolate a portion of the warm, humid air mass. Rain had ceased in New England except in Maine, as the cooler, drier air covered that area; the cold front had moved to central Maine. Another secondary developed east of New England and with the low in Maine moved northward, finally disappearing from the map in Arctic America and Green-

land, November 9–11. The Atlantic high was centered near the Azores, November 11. Just two weeks and four weeks after the storm of November 3–4, 1927, similar, though less intense ones struck northern New York and New England and western New York. Record floods occurred in the Genesee River early in December.

CONCLUSION.

Thus we see that the exceptional rains were due to a rare combination of a great quantity of humid tropical air pushed northward between two flows of polar air, and that the rain was precipitated chiefly where the warm, damp air was forced in large masses over a barrier of mountains backed by a higher barrier of cold air, or where forced to similar heights in a secondary low of small dimensions.

It is worth noting that the great rainstorm of October 3–4, 1869, was of tropical origin and that it was preceded, September 8, 1869, by a hurricane in eastern New England.

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RAINFALL IN NEW ENGLAND DURING THE STORM OF NOVEMBER 3 and 4, 1927.*

BY X. H. GOODNOUGH.†

[*Read, January 11, 1928.*]

The great storm of November 3 and 4, 1927, caused the loss of many lives besides immense destruction of property in large sections of New England. The storm appears to have been general over the northeastern section of the country, extending from Pennsylvania and New York across New England and into Canada. The precipitation was greatest and its results most destructive in Vermont, including adjacent sections of New Hampshire, and in western Massachusetts. At the same time there was a secondary storm which extended from central Massachusetts southerly from the neighborhood of Clinton and Marlborough down the Blackstone valley and along the boundary line between Rhode Island and Connecticut to the sea near Westerly, R. I. The maximum precipitation in the northern storm was over 9 in. in southern Vermont, while in the smaller eastern storm an equal maximum precipitation occurred near the seashore at the Rhode Island-Connecticut boundary.

The area in which there was a precipitation of 9 in. or more amounted to about 457 sq. miles in Vermont and 40 sq. miles in Rhode Island and Connecticut. The rainfall exceeded 8 in. over an area of about 1 660 sq. miles in Vermont and about 135 sq. miles in the Rhode Island-Connecticut and Blackstone River region. The area with a rainfall of 6 in. or more amounted to 7 647 sq. miles in Vermont, New York, New Hampshire, Massachusetts and Connecticut and 827 sq. miles in the Blackstone River region in Massachusetts and in Rhode Island and Connecticut, a total of 8 474 sq. miles, nearly all in New England. This area is about equivalent to the area of the State of Massachusetts.

The areas in which the rainfall exceeded certain specified amounts in each state are given in Table 1. The isohyetal lines or lines of equal rainfall are shown in Plate I.

Such great rainfalls are rare within the limits of New England, but there is evidence that similar storms have occurred from time to time in the past, in some of which the precipitation may have been greater, though it is doubtful whether any similar storm in past years has caused such great loss of life and such destruction of property over so extensive an area as the storm of 1927.

The destructiveness of such a storm depends upon a number of circumstances, important among which are the character of the soil, the con-

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†Chief Engineer, Massachusetts Department of Public Health.

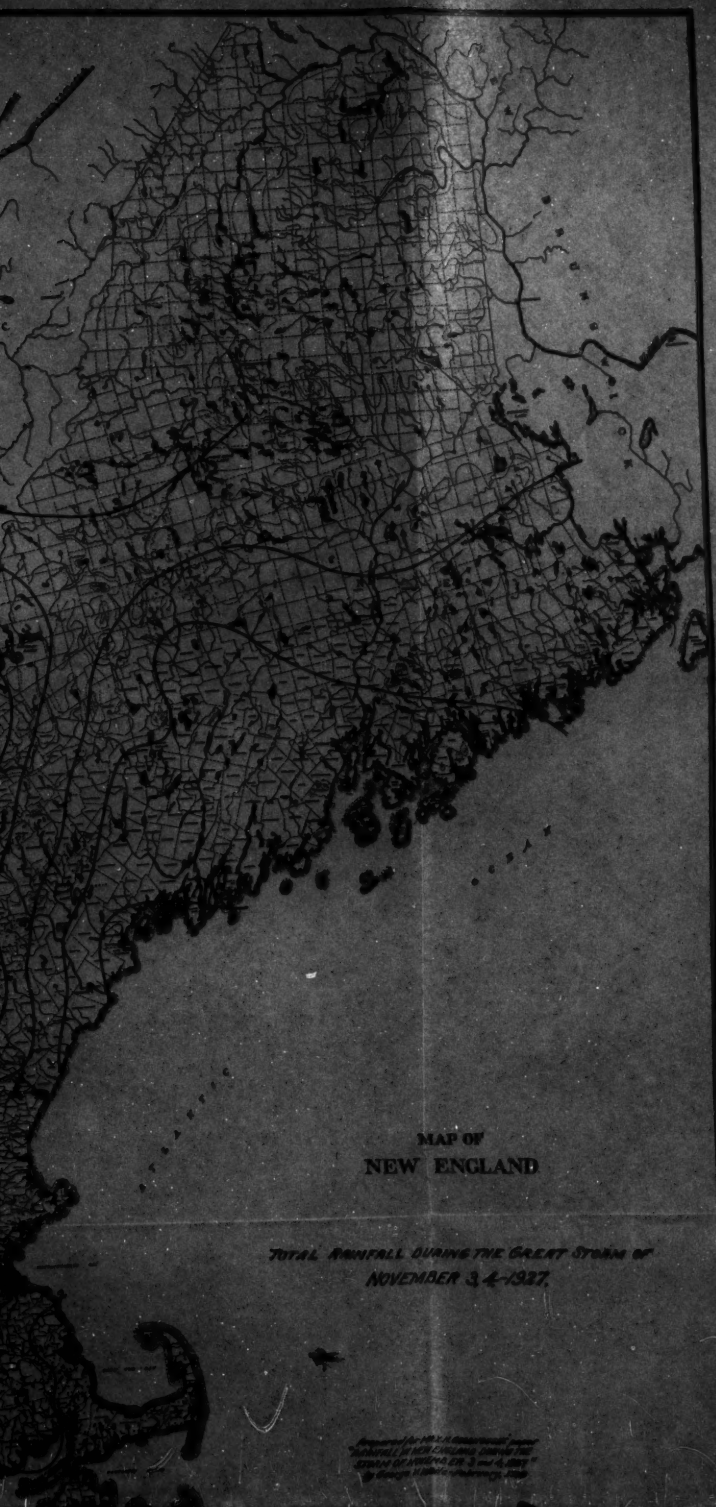
tour and slope of the ground, the condition of the ground and of the streams and ponds at the time when the storm occurs, and the rate of precipitation. The rate of precipitation in this storm was excessive, and fortunately there is much information as to the rate of rainfall at many stations throughout the area affected. The records of the recording gages of the New England

TABLE 1.

AREAS FLOODED BY STORM OF NOVEMBER 3–4, 1927.

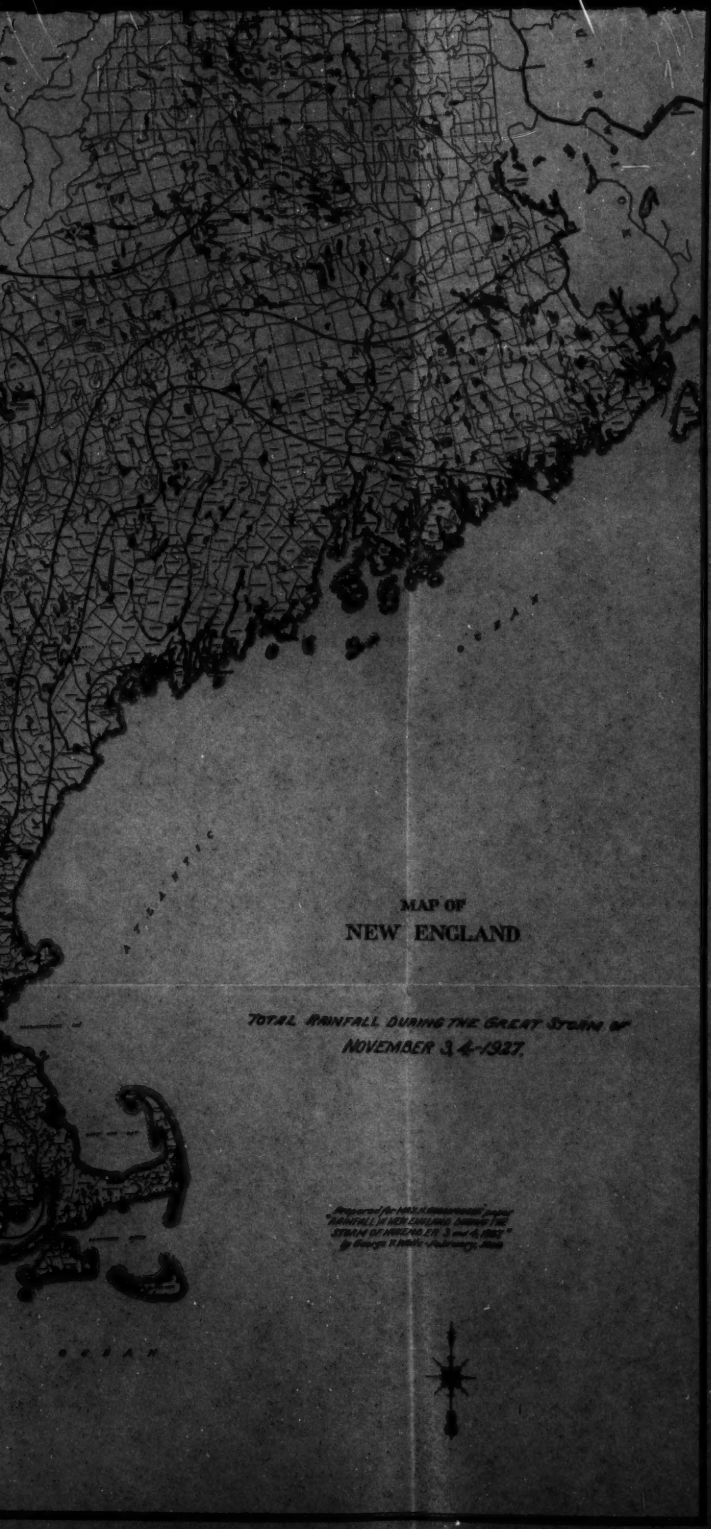
	Square Miles.
Over 9 inches.	
In Vermont	457
In Rhode Island and Connecticut	40
	497
Over 8 inches.	
In Vermont	1 660
In Massachusetts, Rhode Island and Connecticut	135
	1 795
Over 7 inches.	
In Vermont	3 320
In Massachusetts (Western)	220
In Massachusetts (Eastern)	130
In Rhode Island and Connecticut	372
	4 042
Over 6 inches.	
In Vermont and New York	5 530
In New Hampshire	715
In Connecticut	500
In Massachusetts (Western)	902
In Massachusetts (Eastern), and Rhode Island	827
	8 474
Over 5 inches.	
In Vermont and New York	8 135
In New Hampshire and Maine	8 300
In Western Massachusetts and New York	2 680
In Connecticut	920
In Massachusetts (Eastern), Rhode Island and Connecticut	1 999
	22 034

section of the Weather Bureau furnish very definite information as to the rates of precipitation at many places. Records were also made at other points by engineers of water-power companies, officials of water-works systems and other observers in the area covered by the storm. These records are shown in Tables 2, 5, 6 and 7, and in Figs. 1–26. From these records it appears that precipitation was practically continuous for from 28 to 40 hours, the bulk of the precipitation occurring in from 10 to 18 hours in most places. Some of these rates were very high. At Munroe Bridge in the Deerfield valley, rain fell at the rate of 0.28 in. per hour for 16 hours



MAP OF
NEW ENGLAND

TOTAL RAINFALL DURING THE GREAT STORM OF
NOVEMBER 3, 4, 1927.



MAP OF

NEW ENGLAND

TOTAL RAINFALL DURING THE GREAT STORM OF
NOVEMBER 3, 4-1927.

Prepared for MAR. A. ASSOCIATION paper
"RAINFALL IN NEW ENGLAND DURING THE
STORM OF NOV. 3 and 4, 1927."
By George W. Pierce, Attorney, Boston

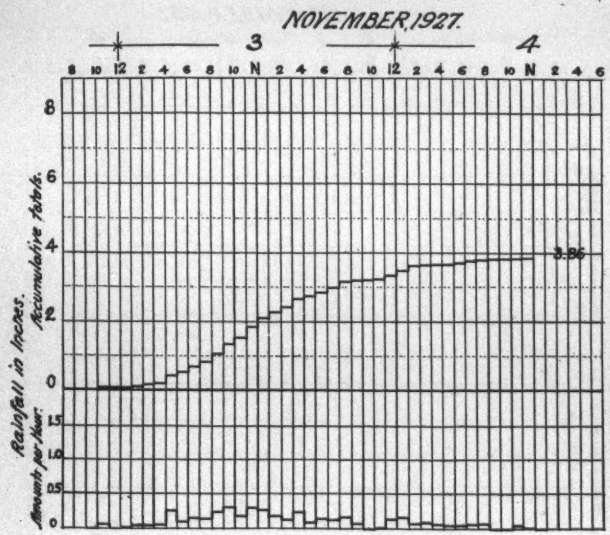


FIG. 1. — RAINFALL AT ALBANY, N. Y.

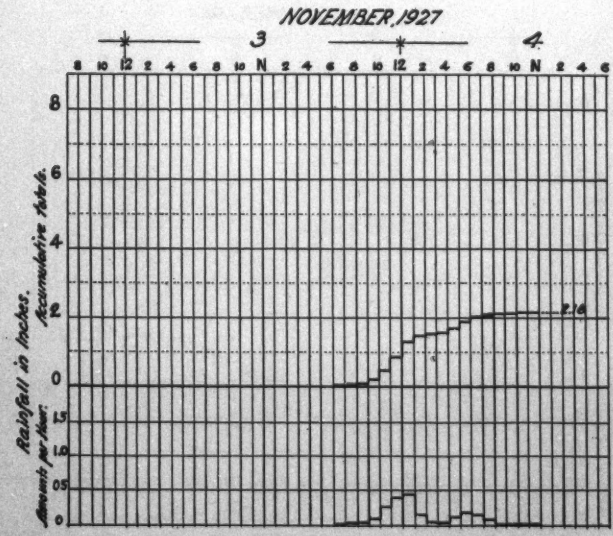


FIG. 2. — RAINFALL AT BLUE HILL OBSERVATORY, BOSTON, MASS.

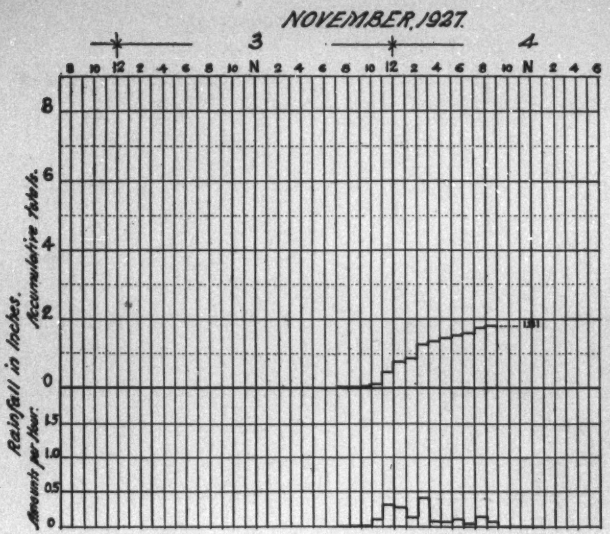


FIG. 3. — RAINFALL AT BOSTON, MASS. (U. S. WEATHER BUREAU.)

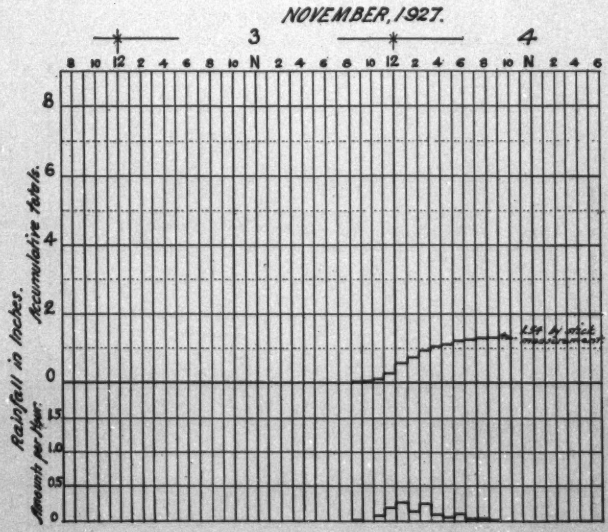


FIG. 4. — RAINFALL AT BROOKLINE, MASS. (TOWN HALL GAGE.)

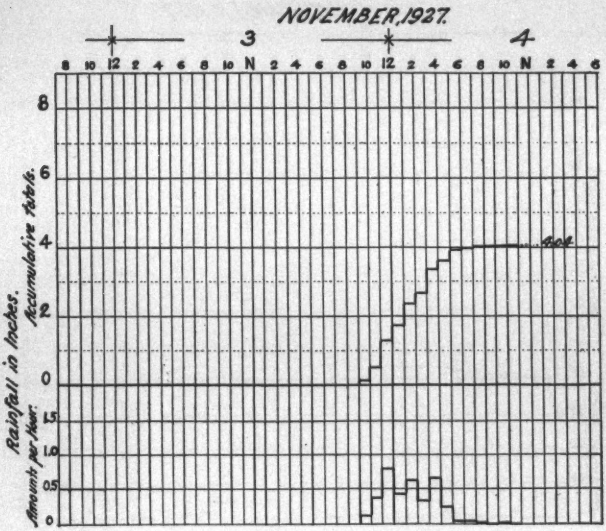


FIG. 5. — RAINFALL AT CONCORD, N. H.

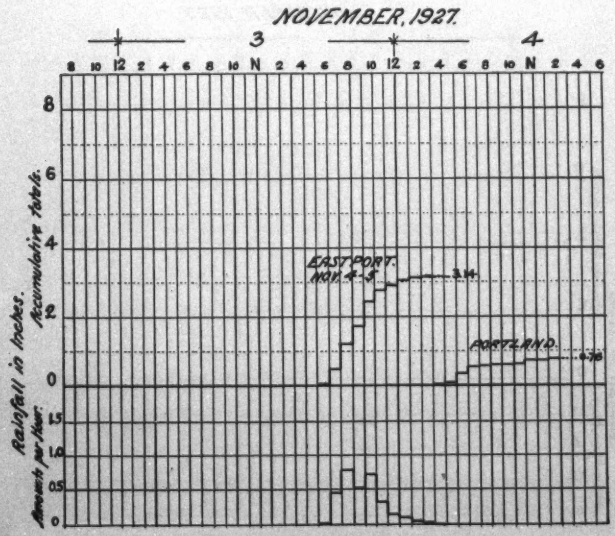


FIG. 6. — RAINFALL AT EASTPORT AND PORTLAND, ME.

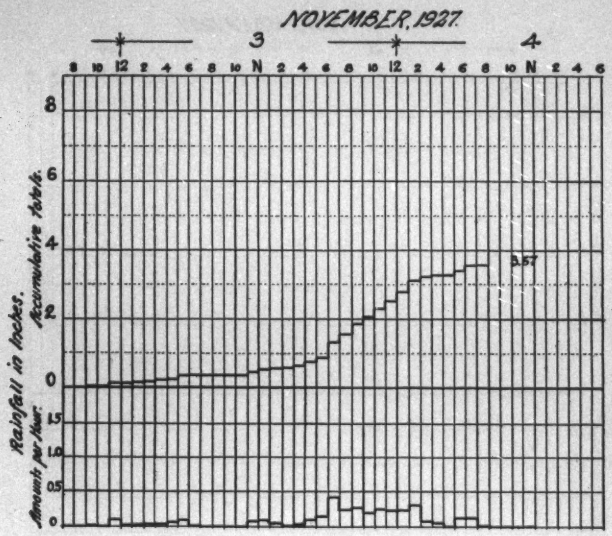


FIG. 7. — RAINFALL AT HARTFORD, CONN.

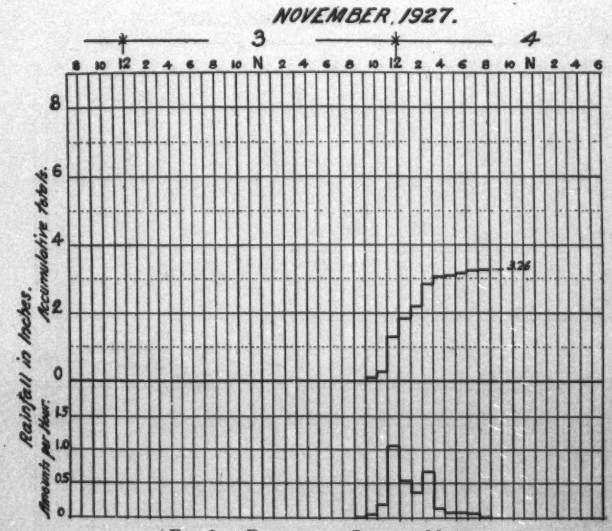


FIG. 8. — RAINFALL AT LOWELL, MASS.

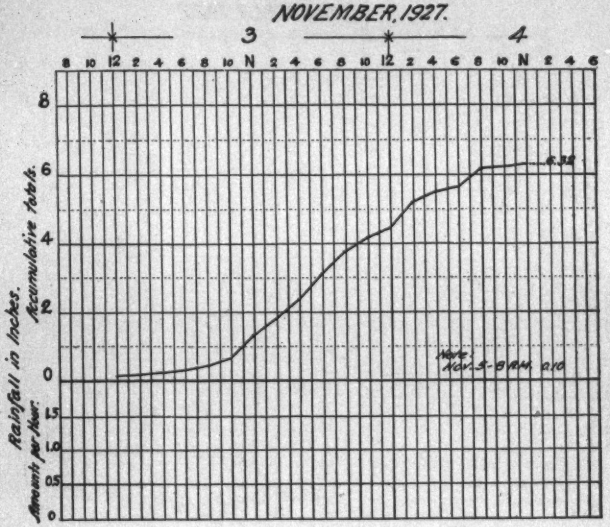


FIG. 9. — RAINFALL AT MONROE, MASS.

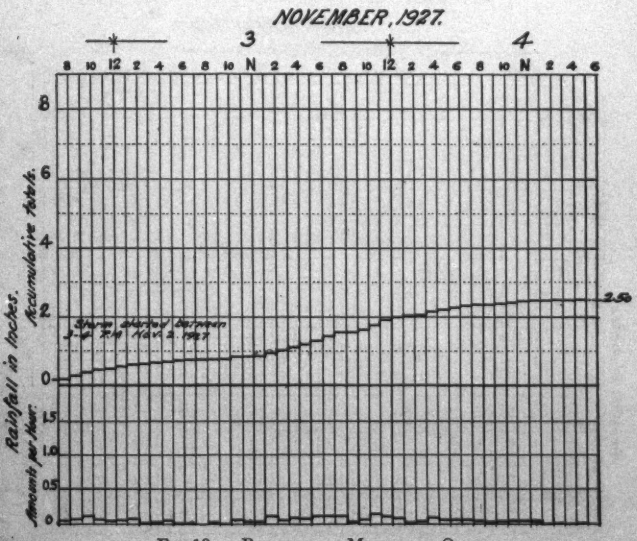


FIG. 10. — RAINFALL AT MONTREAL, QUE.

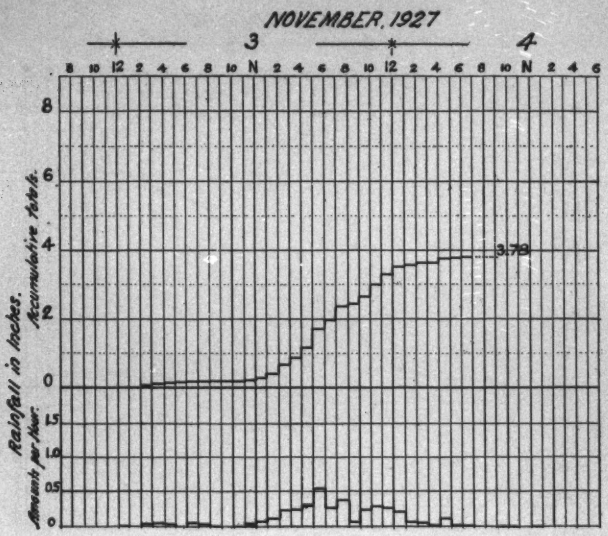


FIG. 11. — RAINFALL AT NEW HAVEN, CONN.

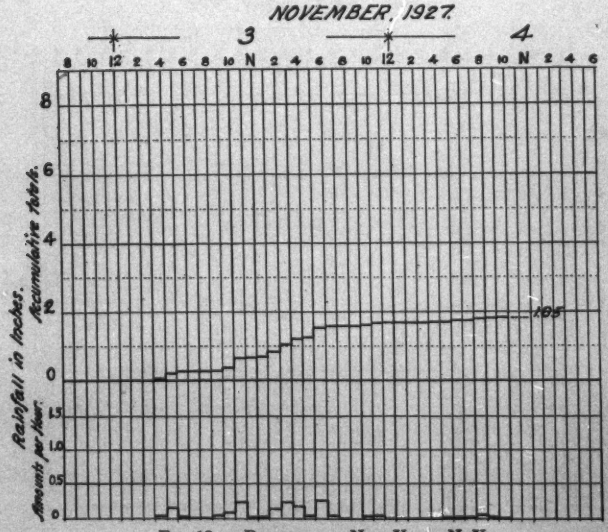


FIG. 12. — RAINFALL AT NEW YORK, N. Y.

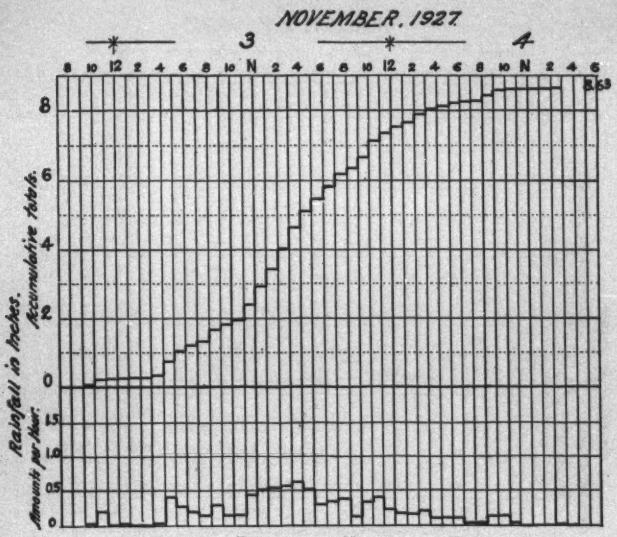


FIG. 13. — RAINFALL AT NORTHFIELD, VT.

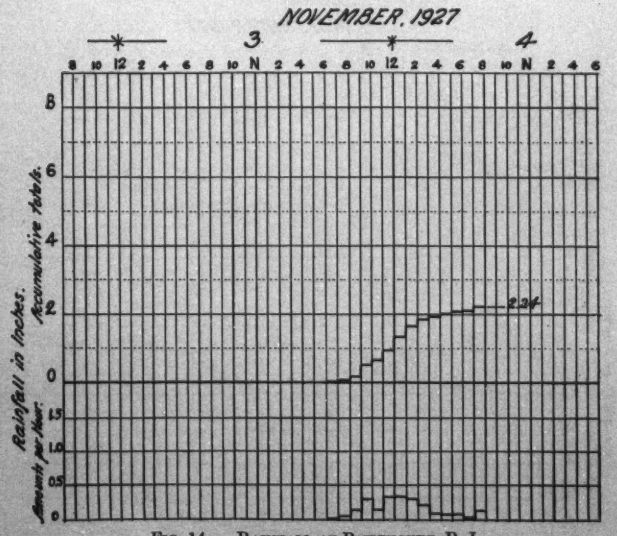


FIG. 14. — RAINFALL AT PAWTUCKET, R. I.

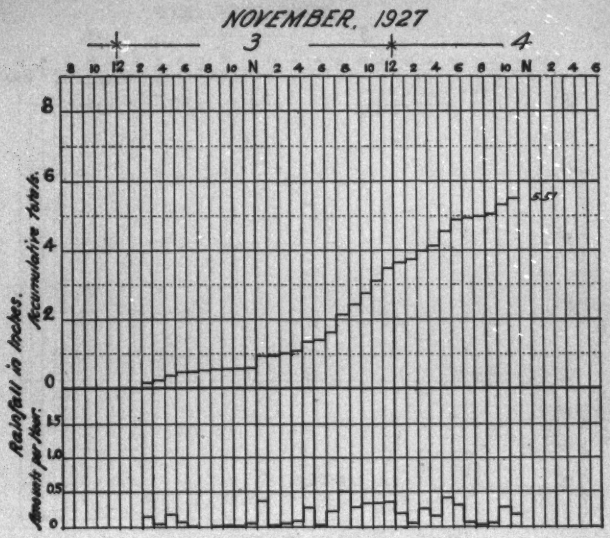


FIG. 15. — RAINFALL AT PHELPS BROOK DAM. (HARTFORD WATER WORKS, BURLINGTON, CONN.)

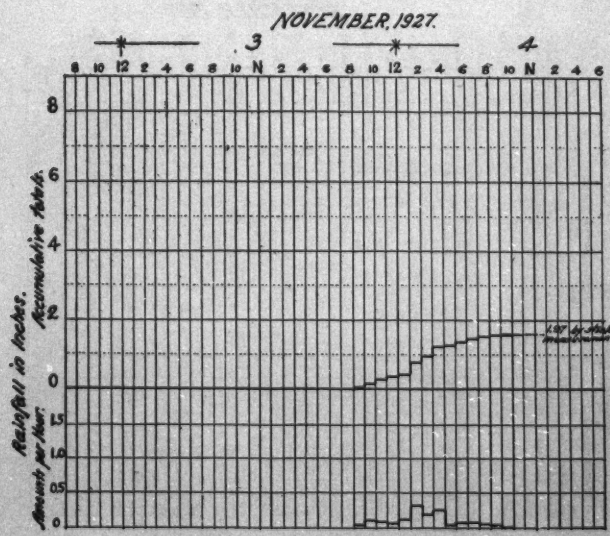


FIG. 16. — RAINFALL AT PROVIDENCE, R. I. (HOPE RESERVOIR.)

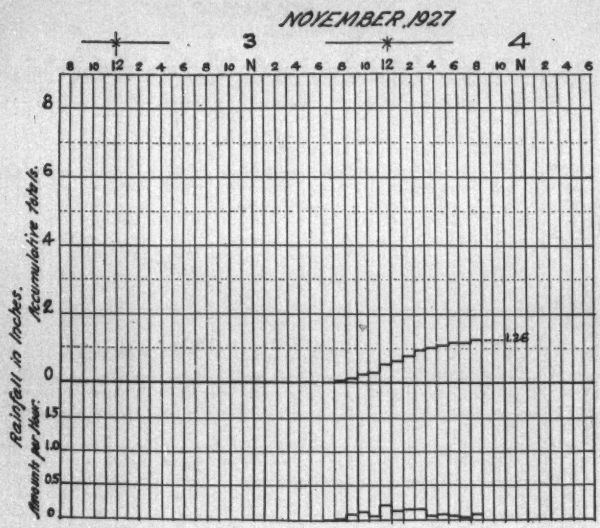


FIG. 17. — RAINFALL AT PROVIDENCE, R. I. (U. S. WEATHER BUREAU.)

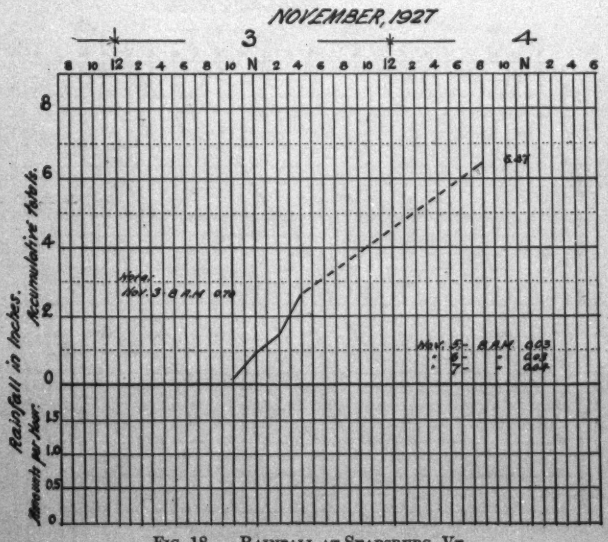


FIG. 18. — RAINFALL AT SEARSBURG, VT.

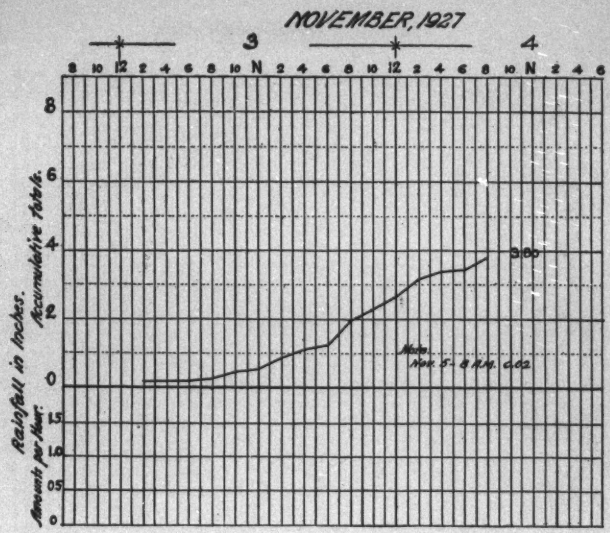

NOVEMBER, 1927
3
4
8 10 12 2 4 6 8 10 N 2 4 6 8 10 12 2 4 6 8 10 N 2 4 6
Rainfall in inches.
Accumulative totals.
Amounts per hour.
3.00
Note
Nov. 5- 8 A.M. 0.02

FIG. 19. — RAINFALL AT SHELBURNE FALLS, MASS.

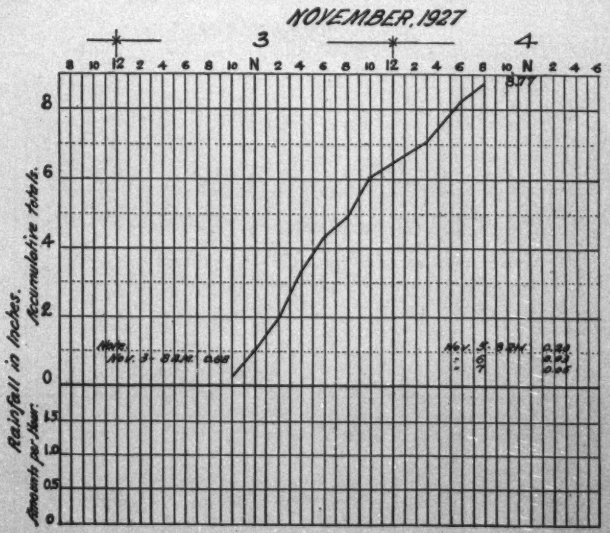

NOVEMBER, 1927
3
4
8 10 12 2 4 6 8 10 N 2 4 6 8 10 12 2 4 6 8 10 N 2 4 6
Rainfall in inches.
Accumulative totals.
Amounts per hour.
3.77
Note
Nov. 3- 8 A.M. 0.00
Nov. 5- 9 P.M.

FIG. 20. — RAINFALL AT SOMERSET, VT.

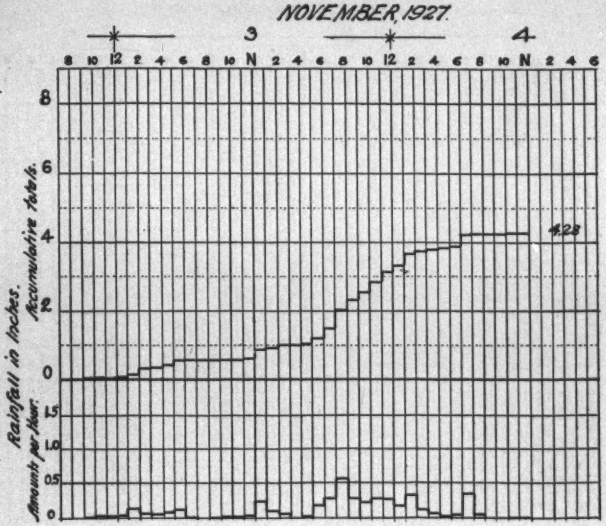


FIG. 21.—RAINFALL AT SPRINGFIELD, MASS.

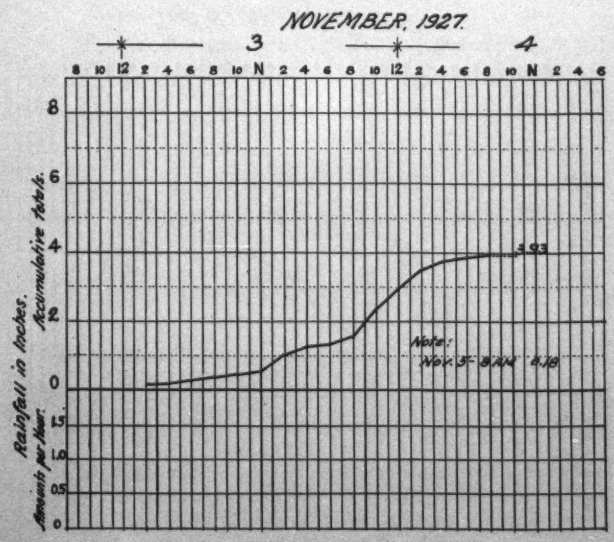


FIG. 22.—RAINFALL AT VERNON, VT.

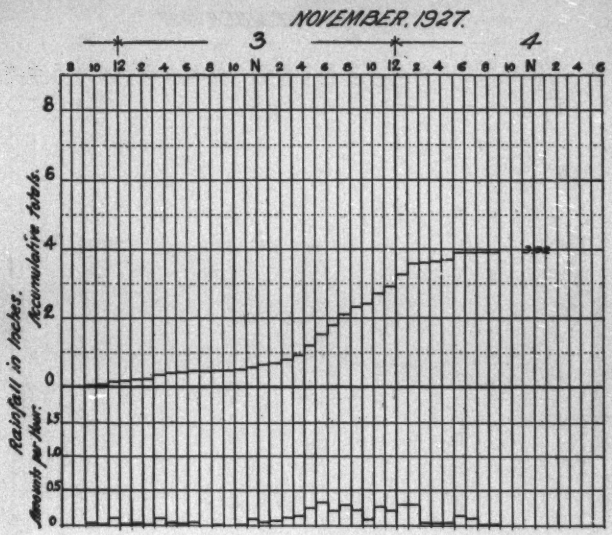


FIG. 23 — RAINFALL AT WEST HARTFORD FILTERS. (HARTFORD WATER WORKS, CONN.)

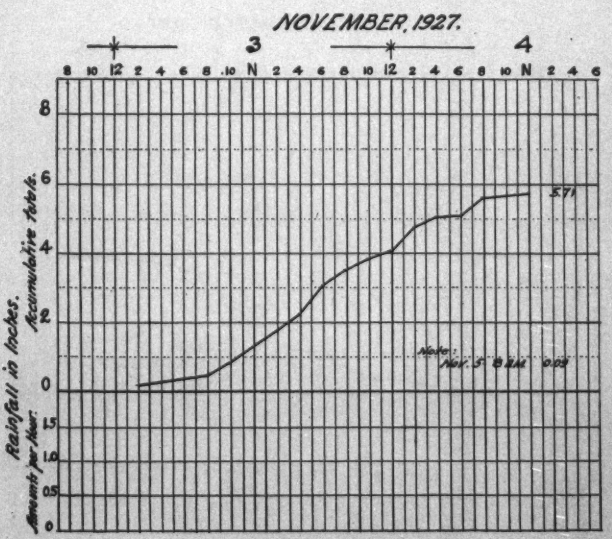


FIG. 24. — RAINFALL AT WHITINGHAM, VT.

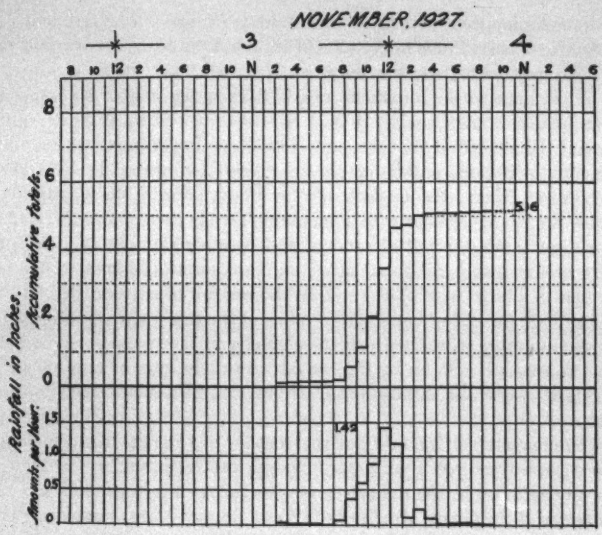


FIG. 25. — RAINFALL AT WORCESTER, MASS. (SEWAGE DISPOSAL WORKS.)

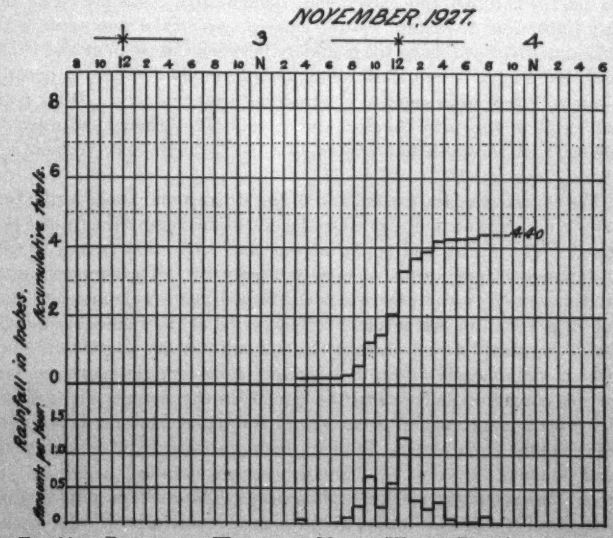


FIG. 26. — RAINFALL AT WORCESTER, MASS. (WINTER HILL OBSERVATORY.)

with a maximum rate for 2 hours of 0.39 in. per hour. At Northfield, Vt., rain fell for a period of 9 hours at 0.44 in. per hour with a maximum rate of 0.62 in. per hour. At Searsburg, Vt., rain fell for 22 hours at a rate of 0.29 in. per hour with a maximum rate of 0.59 in. per hour. At Somerset, Vt., the rate per hour equalled that at Northfield which was 0.44 in., but at Somerset the rainfall at that rate was continuous for 12 hours with a maximum rate for 2 hours of 0.66 in. per hour. At the sewage disposal works at Worcester, Mass., the average rate for 5 hours during the height of the storm was 0.90 in. per hour with a maximum hourly precipitation of 1.42 in. These records are selected at random and possibly rainfalls of greater intensity occurred at some points other than are mentioned here. It is evident that in a large section of Vermont the rainfall nearly equalled half an inch an hour for many consecutive hours, bringing upon the ground an immense quantity of water which the channels of the streams were utterly unable to remove. So far as the records show, the rate of rainfall in the Blackstone valley and in adjacent territory was even more excessive than elsewhere.

The character of the soil and the contour of the region in which this storm occurred favored a very rapid run-off into the streams. The maximum precipitation in the major storm area followed in a general way the main ridges of the Green Mountains in Vermont and Massachusetts. This region is a rugged mountainous country with steep slopes having for the most part a hardpan and clayey soil, though large areas are rocky and nearly impervious to water. In the eastern area in the watershed of the Blackstone River and along the boundary between Connecticut and Rhode Island the country is hilly and rolling with generally a clayey or hardpan sub-soil with few areas capable of absorbing water rapidly. Thus in the area affected by the storm the slope and contour of the ground and character of the soil were favorable to a very rapid run-off, especially in Vermont and western Massachusetts.

The condition of the ground and of the streams and ponds at the time the storm occurred no doubt aided in the destructiveness of the freshet that followed. The winter and spring of the year 1927, that is, the months from January to June, inclusive, were unusually dry. The average rainfall at stations in Vermont and western Massachusetts amounted to only about 72 per cent. of the normal for that period of the year. There have probably been only 4 or 5 years in the last half century in which the precipitation was so small within that period. Following the month of June there was a marked change and the rainfall in the summer and fall was high. The average rainfall at several of the higher stations in Vermont for the months from July to October, inclusive, was 16.56 in., while the normal is about 14.70 in. Far greater excesses obtained in central and western Massachusetts and in Connecticut. The average rainfall from July to October, 1927, inclusive, at the highest stations in western Massachusetts was 20.96, while the normal for those stations is 15.91. The

average rainfall for the month of October at a number of the higher stations in Vermont amounted to about 5.99 in., while the normal is about 3.35 in. In western Massachusetts the rainfall for October was 7.13 in., while the normal for the same stations is 3.58 in.

In the Blackstone valley area the rainfall for the four months previous to the storm amounted to 21.16 in., while the normal is 14.43. In the month of October the precipitation exceeded the normal in that region by about 2.45 in.

The following table shows the rainfall at the various stations during the period July to October, inclusive, 1927.

TABLE 2.

RAINFALL IN THE VICINITY OF FLOODED AREAS FOR THE PERIOD JULY–OCTOBER, 1927.

GAGE LOCATION.	1927.				TOTAL.	NORMAL.				TOTAL.
	Jul.	Aug.	Sep.	Oct.		Jul.	Aug.	Sep.	Oct.	
Northfield, Vt.	3.40	5.92	1.57	5.64	16.53	3.70	3.93	2.76	2.48	12.87
Woodstock, Vt.	4.51	3.24	1.40	5.45	14.60	3.91	3.39	3.46	3.00	13.76
Somerset, Vt.	4.06	4.86	2.75	6.87	18.54	4.60	4.31	4.01	4.56	17.48
Average				5.99	16.56				3.35	14.70
Savoy, Mass.	9.71	3.59	1.01	6.08	20.39	5.25	4.17	3.93	3.78	17.13
Plainfield, Mass.	4.37	3.43	2.36	7.15	17.31	4.62	3.52	4.59	3.74	16.47
Worthington, Mass.	5.33	4.73	2.55	6.87	19.48	4.09	3.72	4.27	3.87	15.95
Chester, Mass.	6.36	6.86	2.49	8.14	23.85	3.95	3.49	3.61	2.94	13.99
Otis, Mass.	6.48	7.88	2.00	7.40	23.76	4.60	4.29	3.56	3.56	16.01
Average				7.13	20.96				3.58	15.91
Wachusett Water Shed	5.94	9.48	3.51	5.02	23.95	4.15	4.09	3.62	3.26	15.12
Worcester, Mass.	5.23	8.70	3.41	5.50	22.84	3.57	3.38	3.35	2.88	13.18
Northbridge, Mass.	3.18	7.45	2.94	6.59	20.16	3.79	4.21	3.39	3.69	15.08
Webster, Mass.	3.06	6.66	2.15	5.80	17.67	3.75	3.81	3.49	3.29	14.34
Average				5.73	21.16				3.28	14.43

In consequence of these conditions the ground preceding the storm was thoroughly saturated, and streams and ponds were full to overflowing, except in the case of a few storage reservoirs having small watersheds in proportion to their capacity which happened to be drawn to a low level before the heavy rain set in early in the summer. These conditions were undoubtedly a main factor in the destructiveness of the storm.

It is of great interest to compare the effect of the excessive rainfall in this storm with the conditions which followed other similar storms in past years. Omitting intense local storms of the thunderstorm type there are fairly good records of rainfalls in the past 50 to 60 years in which the maximum precipitation exceeded 8 in. over a considerable area.

A storm of this type occurred in southern New England on October 12

to 14, 1895, in which the rainfall exceeded 8 in. over an area of some 590 sq. miles, or about 40 per cent. of the area in Vermont in which there was a precipitation of over 8 in. in the recent storm. The storm of 1895 began in southwestern New England at midnight on October 11 and in the northwestern district early on the 12th. In eastern Massachusetts it began about 2 P.M. and in southeastern Maine later in the afternoon on the 12th. In eastern Massachusetts the rainfall ended by 4 A.M. on the 14th and in northern New England before midnight on the 13th.

The heaviest rainfall in this storm occurred in a section of country from North Grosvenordale, in northeastern Connecticut, to Waltham, Mass., covering much the same area as the smaller of the two storms of November, 1927. The area of excessive precipitation, however, extended to the east as far as the seacoast at Boston, the easterly part of this area lying mostly in a comparatively flat country in the watersheds of the Charles and Neponset rivers.

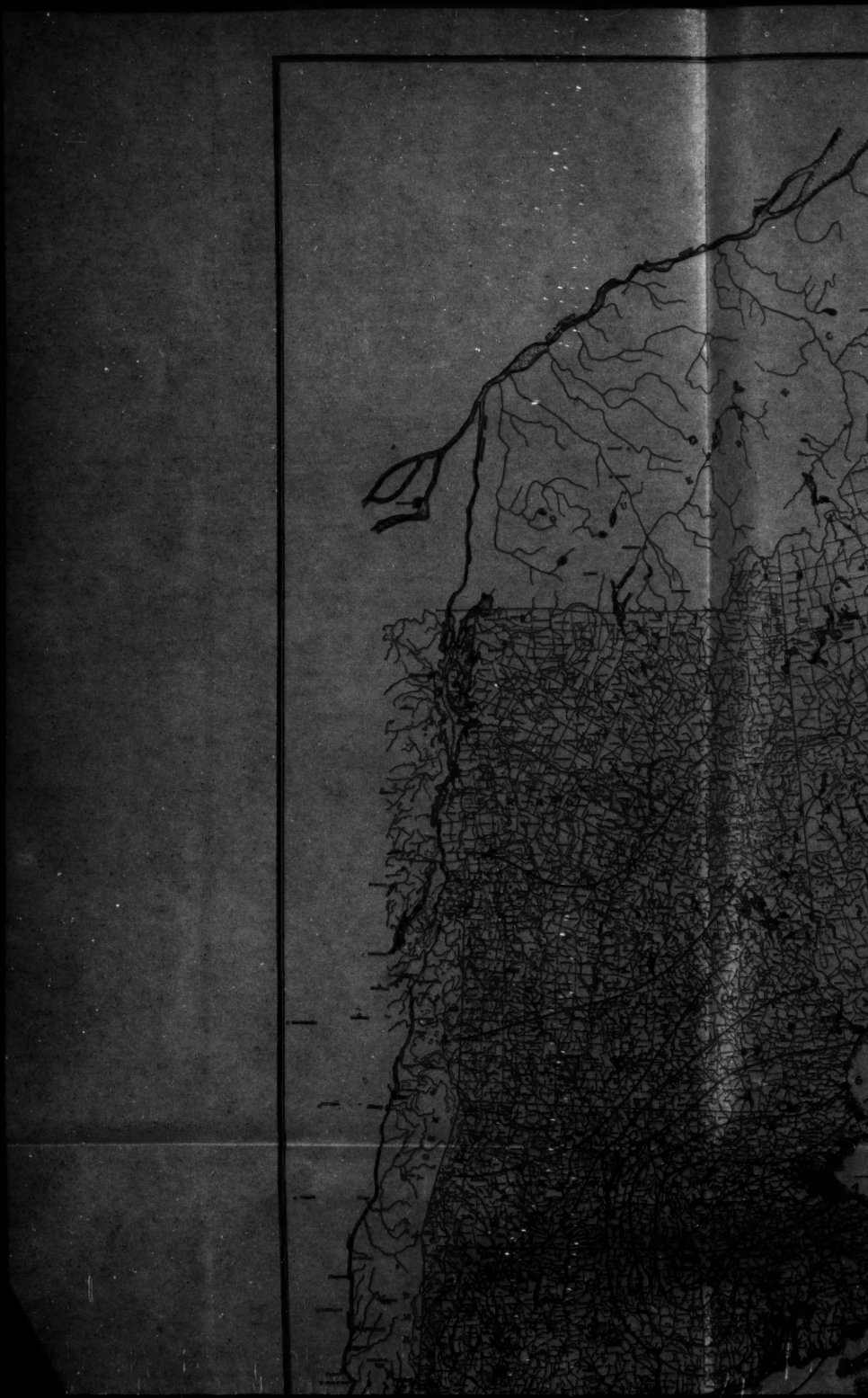
This storm occurred soon after the end of the summer season, some 23 days earlier in the autumn than the storm of 1927, and followed a period of less than average rainfall for that season of the year. Records kept by the late Desmond FitzGerald show that at Chestnut Hill the storm lasted from 1.30 P.M. on the 12th to 4.15 A.M. on the 14th, a period of about 38¼ hours. Thus the storm appears to have been of about the same duration as that of 1927.

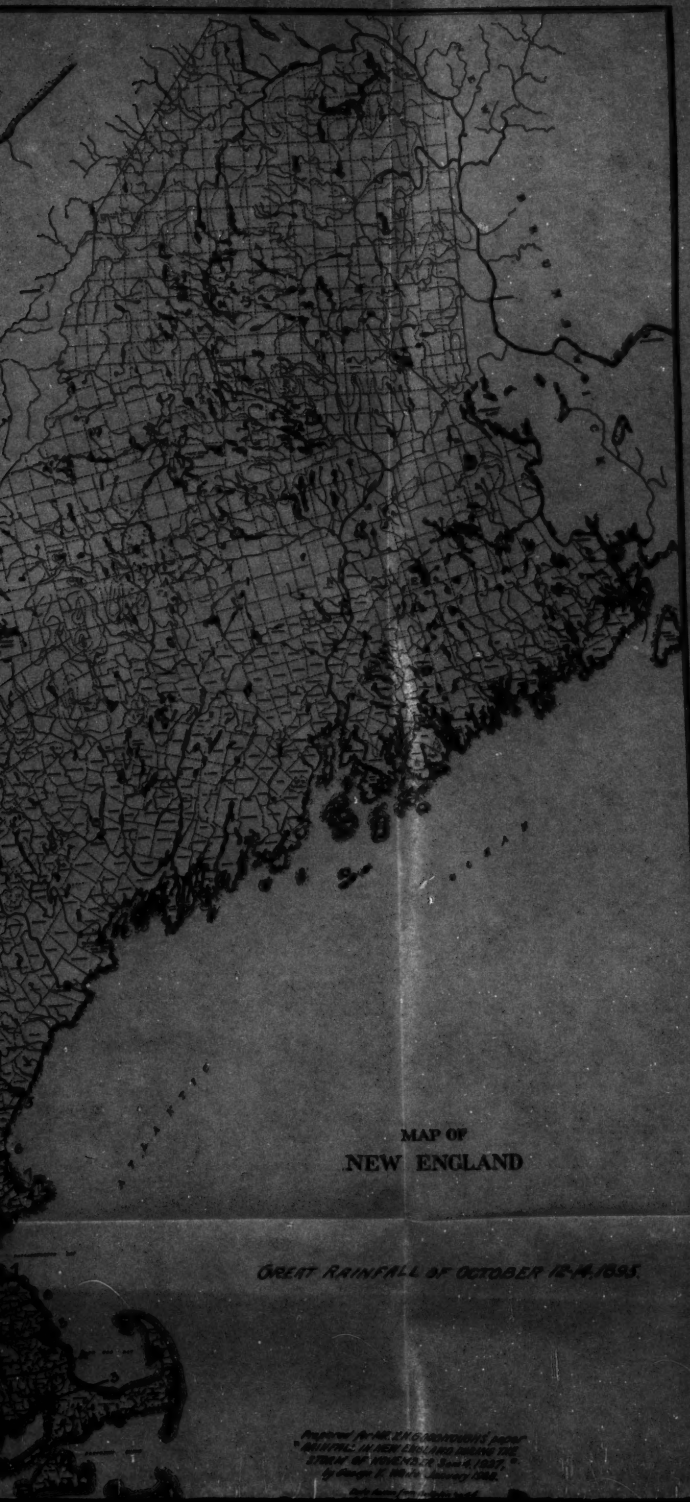
The year 1894 was one of the driest in New England for many years and the rainfall in the winter and early spring months of 1895 from January to April, inclusive, was much less than the average. The rainfall for the 5 months preceding the month of October, 1895, in which the storm occurred, was about 20 per cent. less than the average. For a period of 55 days preceding the storm, however, that is, from August 18 until October 12, the total precipitation in the area covered by the storm amounted to only 3.27 in., while the normal rainfall for that period of the year is about 6.58 in., so that the rainfall had been only about half the usual amount for the 55 days of the drier part of the year just before the storm occurred.

With regard to the rate of precipitation in this storm, satisfactory data are not available, but it is probable that the maximum rates did not vary greatly from those which occurred in areas of similar rainfall in the storm of 1927.

The effects of this storm were slight when compared with the destruction wrought by the storm of 1927. The excessive precipitation produced no serious freshets even in the area of greatest rainfall and no marked damage resulted at any point. The streams were filled but only those low grounds were flooded which are commonly inundated at times of high flow in practically every year.

The following table gives the areas in which the greatest precipitation occurred. The limits of these areas are shown in Plate II.





MAP OF
NEW ENGLAND

GREAT RAINFALL OF OCTOBER 12-14, 1869.

Plate II of N. E. W. W. Association Vol. XLII
"Rainfall in New England during the Storm of November 3 and 4, 1927."
By George E. Goodnough, January 1928.

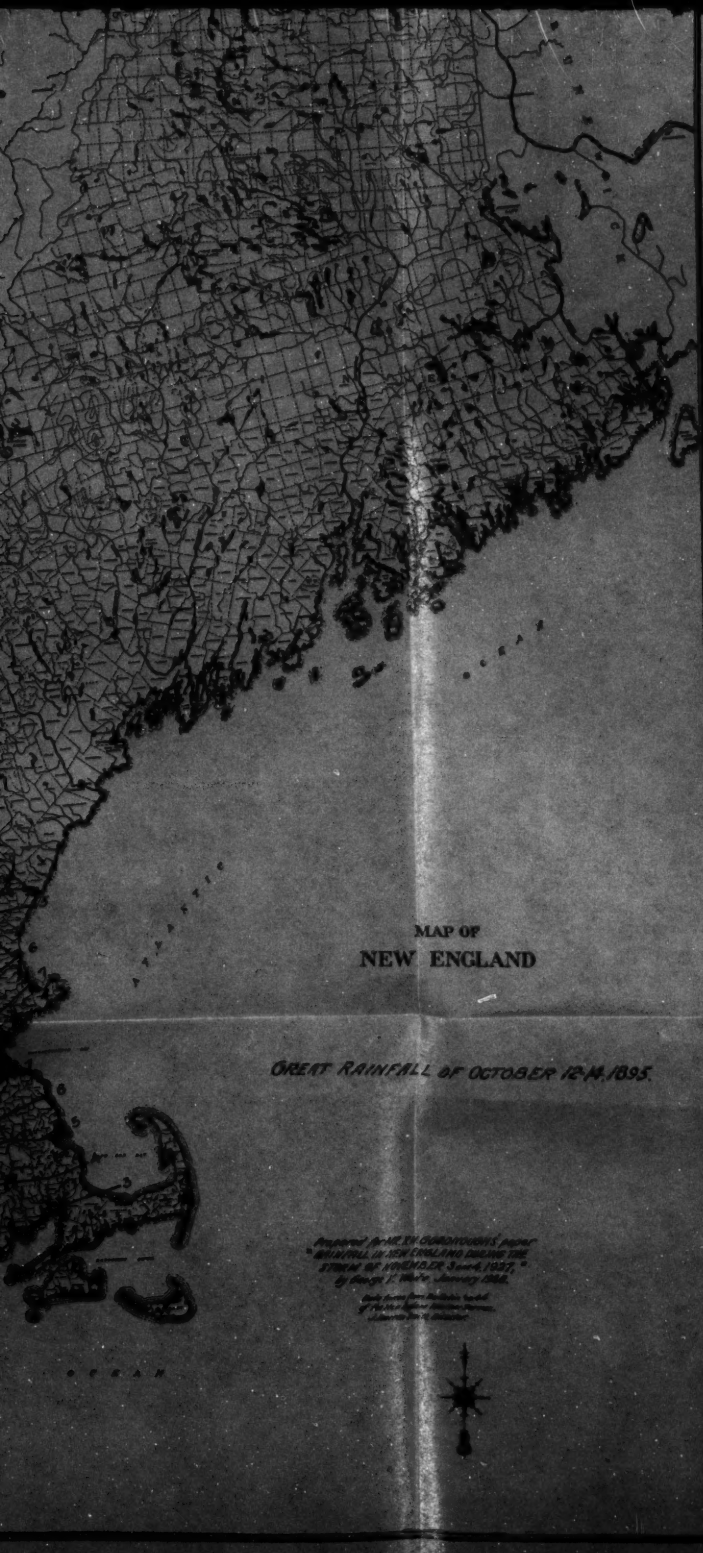

MAP OF
NEW ENGLAND
GREAT RAINFALL OF OCTOBER 12-14, 1895.
OCEAN

TABLE 3.

AREAS FLOODED BY STORM OF OCTOBER 12–14, 1895.

Over 8 inches.	*Square Miles.*
In Massachusetts	400
In Rhode Island	70
In Connecticut	120
	590
Over 7 inches.	
In Massachusetts	1 630
In Rhode Island	165
In Connecticut	250
	2 045
Over 6 inches.	
In Massachusetts	3 030
In Rhode Island	435
In Connecticut	605
	4 070
Over 5 inches.	
In Massachusetts	4 070
In Rhode Island	710
In Connecticut	1 020
In New Hampshire	540
	6 340

On February 10–14, 1886, occurred a rain storm which created the greatest freshets that had been recorded in southeastern New England for the last 40 years, previous to the storm of 1927. The conditions in this storm were vastly different from those which obtained either in the storm of 1927 or in that of 1895. The storm of 1886 is quite fully described in a paper by Winslow Upton, at that time director of the New England Meteorological Society, which is printed in *Science*, March 19, 1886, p. 163. The extent of territory covered by the rainfall is given by Mr. Upton as follows:

Amount of Rainfall.	*Area in Square Miles.*
Over 8 inches	750
Between 7 and 8 inches	750
Between 6 and 7 inches	1 500
Between 5 and 6 inches	1 850
Between 4 and 5 inches	2 750

This storm passed northeasterly diagonally across the State of Rhode Island from the Connecticut boundary and across the State of Massachusetts to the sea south of Boston, the heaviest precipitation occurring in the neighborhood of Providence. The territory affected was a little farther

to the southeast than in the storm of 1895 or in the secondary storm in November, 1927. Plate III shows the lines of equal rainfall in this storm.

The time of beginning and ending of the storm of 1886 at several stations along its course is given by Mr. Upton as shown in the following summary:

Stations.	*Time of Beginning.*	*Time of Ending.*
New York	10th, 10.30 A.M.	13th, Noon
New London	11th, 6.00 A.M.	13th, 4.20 P.M.
Providence	11th, 1.00 A.M.	13th, 11.30 P.M.
Boston	11th, 7.45 A.M.	13th, 2.45 P.M.
Newburyport	10th, 5.30 P.M.	13th, 10.30 P.M.

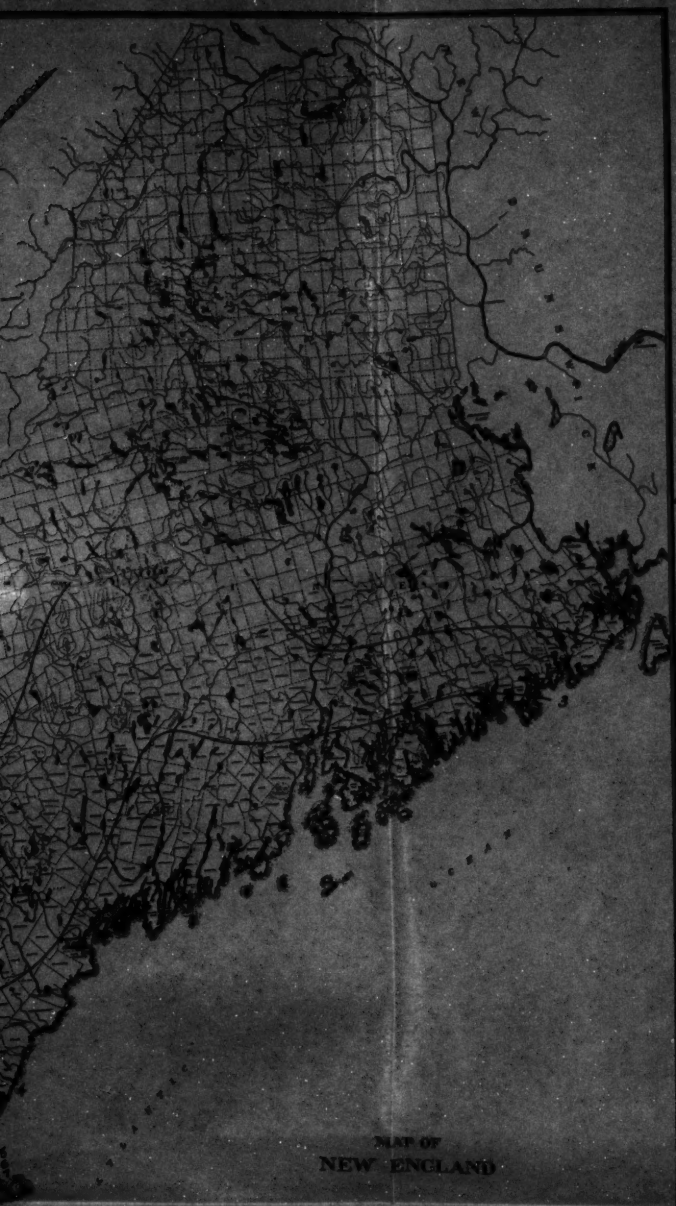
The maximum rainfall in 24 hours at several stations during this storm is given as follows:

New York	2.99 inches.
New London	6.66 inches.
Providence	5.65 inches.
Boston	4.45 inches.
Newburyport	3.30 inches.

At the time this great rain began the ground was deeply covered with snow, the depth of the latter, as estimated generally by observers at that time, probably amounting to about 2 in. of rainfall. At the beginning the temperature was rather low and much of the rain was absorbed and held in suspension by the snow, comparatively little running off into the streams during the 11th and early part of the 12th. The temperature remained very nearly stationary during the 11th and the 12th, at a few degrees above the freezing point, but rose on the night of the 12th and the morning of the 13th to above 50° F., and it was at the time of this rise in temperature that the bulk of the precipitation occurred.

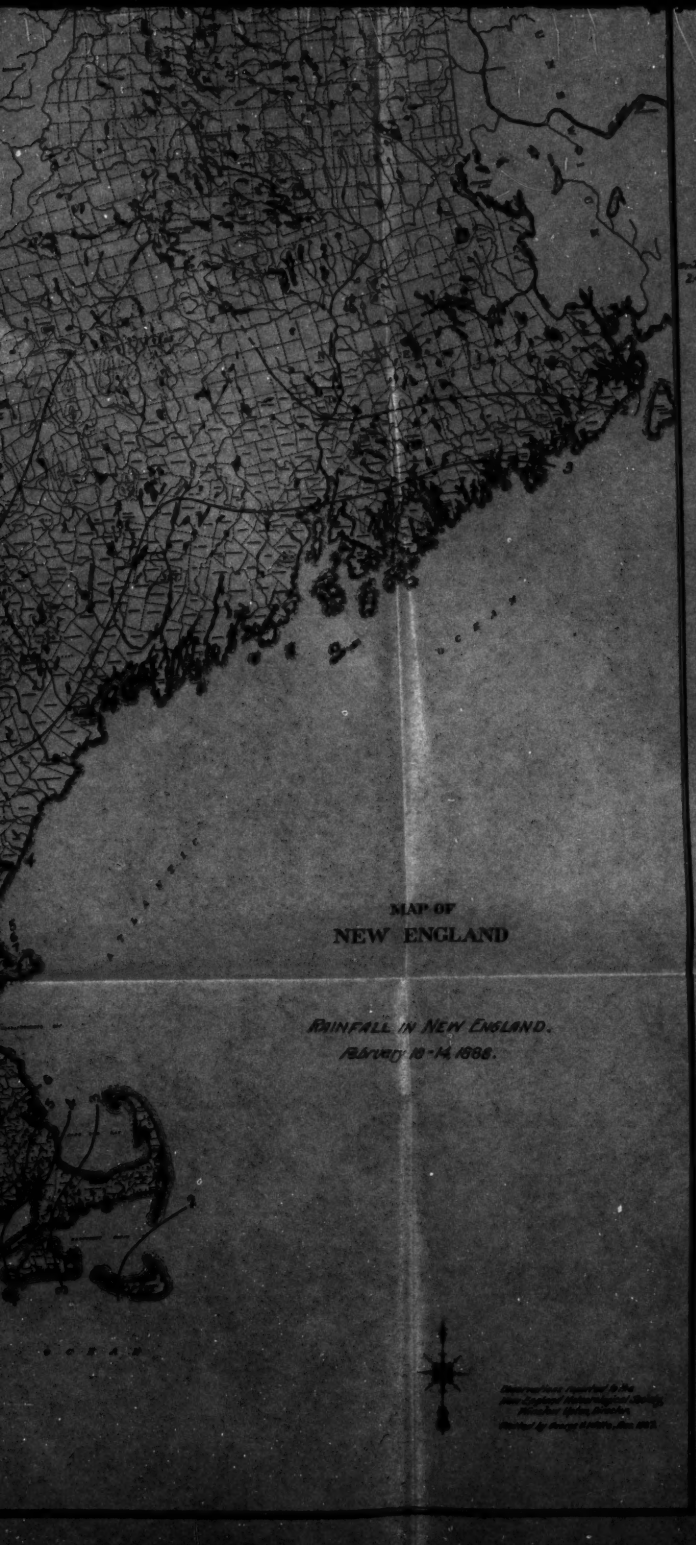
The effect of these conditions was to bring practically the entire quantity of snow on the ground, together with the bulk of the rainfall, into the streams within a comparatively few hours, producing the greatest freshets which apparently were ever recorded in southeastern New England up to that time. It produced an extraordinary flood in Stony Brook in the southern part of the city of Boston which inundated a thickly populated district, besides doing great damage in many other cities and towns in Rhode Island, Connecticut and eastern Massachusetts. The records of this flood have furnished a basis for the design of many conduits, channels and other engineering structures in this region since that time.

In 1878 a great freshet occurred in the Westfield River on December 10 following a precipitation of 3.18 in. of rain and snow. According to the accounts the ground was deeply frozen previous to the storm, which began in the form of snow, turning to rain when a depth of about one foot of snow had fallen. As the storm turned to rain the temperature rose very rapidly



MAP OF
NEW ENGLAND

RAINFALL IN NEW ENGLAND.
FEBRUARY 10-14, 1886.



MAP OF
NEW ENGLAND

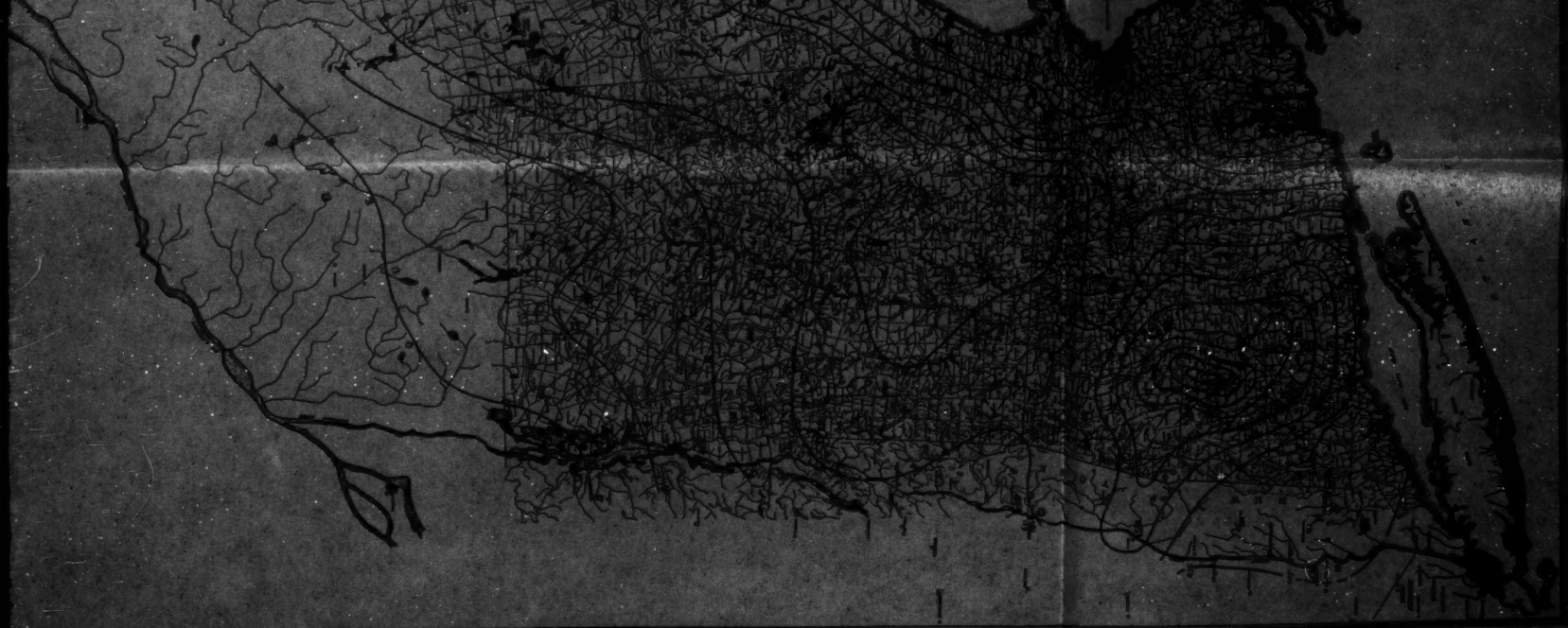
RAINFALL IN NEW ENGLAND.
FEBRUARY 10-14, 1888.

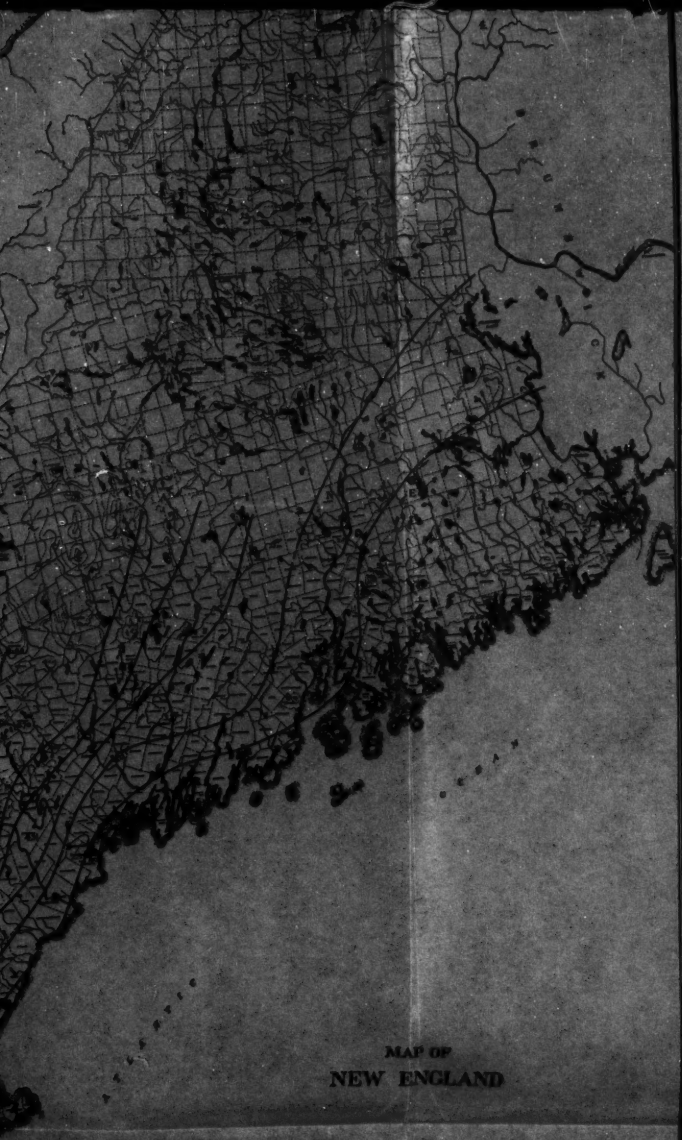
PLATE IV.
N. E. W. W. ASSOCIATION.
VOL. XLII.
GOODNOUGH ON
RAINFALL IN STORM OF
NOVEMBER, 1927.

MAP OF
NEW ENGLAND

RAINFALL IN NEW ENGLAND.
OCTOBER 3-4, 1869.

From the notes of Jonas A. Fessenden accompanying a paper read by him at the Convention of the American Society of Civil Engineers held in Boston June 8th, 1870. Plotted by Geo. H. Haines, January, 1928.





MAP OF
NEW ENGLAND

RAINFALL IN NEW ENGLAND.
OCTOBER 3-4, 1869.

From the atlas of Storm & Flood accompanying report read by him at the Convention of the American Society of Civil Engineers, held in Boston, June 1870. Plotted by Francis C. Wilkins, January 1928.

and the snow melted very quickly which, together with the rain which it had absorbed, ran rapidly off into the river, producing a great freshet in that stream which inundated the town of Westfield. A report as to this storm and its effects, dated February, 1879, was made to the town of Westfield by the late Hiram F. Mills, A.M., C.E., who was engaged by a committee to report a plan for the permanent protection of the town from future floods.

The maximum rate of flow in the river resulting from this rainfall as estimated by Mr. Mills was 53 000 cu. ft. per sec. over a drainage area of 350 sq. miles, equal to about 51 cu. ft. per sec. per sq. mile.

In 1874 a very considerable freshet occurred in eastern New England which resulted in a flow in the Sudbury River nearly equal to that of February, 1886. It was during this freshet that the Lynde Brook Reservoir of the Worcester water supply system was carried away.

One of the greatest freshets that ever occurred in New England resulted from the great rain of October 3 and 4, 1869. The storm is quite fully described by the late Mr. James B. Francis, the famous engineer, in a paper which was presented to the convention of the American Society of Civil Engineers held in Boston in June, 1878.

The storm was most intense in the Connecticut River valley but was very serious throughout central and northern New England, extending into Maine and beyond. The number of rainfall stations in existence in 1869 was comparatively small and it is very difficult to map this area accurately, but it is evident from the newspaper reports of the day that the freshet caused great destruction in a wide area of New England. At Concord, N. H., it began raining on the night of October 2, and up to daylight on October 5 over 2 in. had fallen. From that time until 4 P.M., that is in a period of about 10 hours, the newspapers state that there was a fall of 6 in., making the total precipitation at that point about 8 in. The newspapers complained that they had no exchanges except in eastern New England for many days. The maximum rainfall in this storm as shown by Mr. Francis's paper occurred at Canton, Conn., with a precipitation of 12.35 in.

The storm extended through the center of New England from western Connecticut, across the States of Massachusetts and New Hampshire, and into Maine. The rainfall exceeded 7 in. in an area of 3 901 sq. miles in Connecticut, southwestern Massachusetts, and adjacent parts of New York, and also exceeded 7 in. in an area of over 3 253 sq. miles in central New Hampshire and adjacent portions of Vermont and Massachusetts. The areas in which the rainfall exceeded certain specific amounts in each state are given in the following table, and the lines of equal rainfall are shown in Plate IV. The map covers a much larger area than is shown in Mr. Francis's paper and has been prepared by the use of available records of rainfall observations of that period.

TABLE 4.

AREAS FLOODED BY STORM OF OCTOBER 3–4, 1869.

	Square Miles.
Over 12 inches.	
In Connecticut	40
Over 11 inches.	
In Connecticut and Massachusetts	255
Over 10 inches.	
In Connecticut and Massachusetts	370
Over 9 inches.	
In Connecticut	667
In Massachusetts	235
	902
Over 8 inches.	
In Connecticut	1 450
In Massachusetts	814
	2 264
Over 7 inches.	
In Connecticut	2 333
In Massachusetts (S. W. Section) and New York	1 568
In Massachusetts (Central)	333
In New Hampshire	2 508
In Vermont	412
	7 154
Over 6 inches.	
In Connecticut	3 314
In Massachusetts	3 304
In Vermont	1 804
In New Hampshire	5 150
	13 572

It is interesting, though somewhat futile, to attempt to study records of great storms occurring previous to 1869, since the number of rainfall stations diminishes rapidly going back through the years, and there are only two continuous records of rainfall in New England previous to 1825. There was unquestionably a great rain storm in August, 1826, which covered much of eastern New England as far north as the White Mountains, and the Willey House slide by which the Willey family was destroyed in the Crawford Notch in August, 1826, was no doubt a result of this storm. The records of rainfall at Boston and Lowell show a precipitation for the month of August, 1826 in excess of 9 in., and it is recorded that at Salem the total rainfall for the month was 14 in.

The New Bedford records for that month as hitherto printed show a total of 18.72 in., but a copy of the original rainfall record at New Bedford

made by Thomas R. Rodman, which has been supplied by the Blue Hill Meteorological Observatory with which the original record is now deposited, shows the following precipitation for the month of August, 1826.

August.	Amount (Inches).	August.	Amount (Inches).	August.	Amount (Inches).
1	.05	12	3.36†	23	...
2	...	13	2.50	24	1.33
3	...	14	.04	25	1.83
4	...	15	.01	26	.05
5	...	16	.03	27	...
6	...	17	...	28	...
7	1.74	18	.24	29	.05
8	.07	19	.02	30	...
9	...	20	...	31	...
10	...	21	.09		
11	4.83*	22	.40	Total	16.64

*Thunder and lightning and great rain.
†Much rain. Thunder and lightning in the night.

From this record it appears that there was a total precipitation of 10.69 in. from August 11 to 13 in that year and later 3.16 in. on August 24 and 25. The total for the month is 16.64, instead of 18.72 in. as previously given, the highest ever recorded for a single month at New Bedford and has been exceeded elsewhere in New England only at Lawrence in August, 1856, so far as known.

Finally, it seems worth while to refer to the great freshet in the Merrimack River in October, 1785. During that year a record of rainfall was kept at Andover by the Rev. Jonathan French from which it appears that the total rainfall in the month of September was 9.2 in., and in October, 10.1 in. The bulk of the rainfall in the month of October apparently occurred on the 20th, when it is said that 9 in. of water had fallen on the previous 3 days. It produced the greatest freshet in the Merrimack River that had been recorded in that stream previous to 1896, and the late Hiram F. Mills, for so many years in charge of the water powers at Lowell and Lawrence, once stated that he believed that the freshet of 1785 probably carried more water than that of 1896, the higher rise in the latter case probably being due to obstructions along the stream that did not exist in 1785.

A study of these storms indicates the great importance in estimating the effect of an excessive rainfall and giving due consideration to the conditions under which it may occur. A rainfall of 8 or 9 in. even though falling at a very rapid rate may produce comparatively little effect in a fairly level country at the end of a very dry period in summer or early fall compared with the effect that it may produce upon frozen ground or ground covered with snow or upon ground which has been thoroughly saturated by earlier storms. In the light of the recent observations it is most desirable that careful attention be given to the spillways of dams and reservoirs since the

greatest destruction of all occurs where a reservoir dam is carried away in a great rain storm. It may be of interest to add that during the recent freshet a reservoir constructed not long before under capable engineering advice nearly proved a victim to the excessive rainfall in that storm. The waste-way was constructed, it was thought, of ample size to prevent the water from overflowing the main part of the dam which, as it was constructed of earth, would be likely to go out if seriously eroded. At the height of the freshet the water rose for a very short time to a depth of 1.5 to 2 in. over the top of the earth portion of the dam, but a thick growth of grass rendered luxuriant by the frequent rains of the summer and fall prevented any serious erosion during the short period when this overflow occurred.

It is impossible to give a very definite estimate as to the frequency of the occurrence of such storms as that of November 3 and 4, 1927, within the limits of New England. We have evidence that they have occurred four times since 1869, that is on an average about once in 15 years, and there are quite reliable records of at least six such storms in the last 140 years, so that we may safely estimate that such storms may occur on an average as often as at least once in about 20 years.

The records of rainfall in New England cover so brief a period, however, that it is impossible to reach definite conclusions in this matter. The longest continuous rainfall record in New England is that at New Bedford, which has now been maintained for a period of 114 years. There is an available record at Boston for 109 years, at Lowell for 102 years, and at Waltham for 101 years, making four records that cover a period of a century. This period is comparatively so brief, however, that it is impossible to reach definite conclusions as to the frequency of great storms such as that of 1927, and the best estimate seems to indicate that they may occur in New England four or five times in a century. It is to be remembered, however, that there may have been greater freshets in the past which had less serious effect than the more recent ones because of the smaller population of the country at the time they occurred, and it is important to take into account in estimating the effect of future freshets the probable influence of structures along or over the streams in raising the level of the water or perhaps in retarding its flow. In any case, great as the recent freshet was, it is unsafe to assume that even the excessive precipitation in the recent storm will not at some time be exceeded.

Much has been said of the effect of storage reservoirs in reducing the height of water in freshets, and considerable popular misapprehension appears to exist on the effect of such reservoirs under such circumstances. If the rainfall happens to occur when the reservoirs have been drawn down the storage will of course help materially in reducing the intensity of the freshet, but when the reservoirs are full, or nearly so, the reduction would be comparatively small, unless the reservoir was of very large size in proportion to its watershed. There is no doubt that any pond or reservoir, even when full, reduces the maximum height of a freshet because of the

temporary storage which is made available by the rise of the water at such a time; but storage reservoirs that are to be used for the purpose of preventing or reducing freshets on a river to be most effective must be maintained with that purpose always in view. In order that they may be of value when the freshet occurs the storage capacity of such reservoirs, or at least that portion of it designed for relief from freshets, must be available at all times, otherwise their usefulness may be slight when the occasion to use them arises.

The records of rainfall upon which the map of the great storm of November, 1927, is based are given in the following tables. They include the records of the numerous rain gages of the Weather Bureau in all parts of New England and the adjacent sections of New York, the records of the Department of Public Health in Massachusetts, and the results of observations by various power companies, water departments and companies, and private observers.

Acknowledgments are due to the coöperation of the many observers who have supplied information given in the tables and especially to Mr. George A. Loveland, Meteorologist of the Boston Weather Bureau; Mr. H. B. Kinnison, District Engineer of the United States Geological Survey; Mr. J. Henry Weber of Clark University; Messrs. Arthur T. Safford and S. S. Kent, Chief Engineer and Assistant Engineer, respectively, Locks and Canals, Lowell; and to Messrs. Trotter & Cate, of Montreal. The work of compiling the records and the preparation of plans and diagrams have been carried out for the most part by Mr. Geo. V. White of the Department of Public Health.

Tables and diagrams are also appended showing the rate of precipitation at a number of places during this storm, the information having been furnished chiefly by the Weather Bureau, the New England Power Company and Mr. Safford.

TABLE 5.

RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

Maine.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2-5 Inc.	Nov.2-4 Inc.
Aziscohos Dam	...	...	...	...	...	...	3.71	...
Bangor	...	...	...	.06	1.84	...	1.90	0.06
Bar Harbor	.02	...	...	1.95	...	...	1.95	1.95
Danforth	...	...	...	.80	1.55	...	2.35	0.80
Eastport	...	...	...	2.93	.21	...	3.14	2.93
Ellsworth	...	...	...	3.25	...	...	3.25	3.25
Eustis	.03	...	.64	2.81	.06	...	3.51	3.45
Farmington	...	...	.35	2.02	.00	.00	2.37	2.37
Fort Fairfield	.00	.00	.05	.04	1.99	.00	2.08	0.09
Fort Kent	...	...	.50	2.00	...	...	2.50	2.50
Gardiner	.02	...	.02	1.64	.02	.00	1.68	1.66
Greenville	...	...	.44	2.90	.04	...	3.38	3.34
Hiram	...	...	...	2.90	...	...	2.90	2.90
Houlton	...	...	.51	.25	1.83	T.	2.59	0.76
Jackman	...	.01	.41	1.62	.02	...	2.06	2.04
Lewiston	...	...	.06	1.38	T.	...	1.44	1.44
Lincoln	...	...	...	1.42	...	...	1.42	1.42
Machias	.03	...	...	1.40	...	...	1.40	1.40
Madison	...	...	.18	1.29	T.	...	1.47	1.47
Middle Dam	...	...	...	...	...	...	5.14	...
Millinocket	.00	.45	T.	3.73	.00	.00	4.18	4.18
Milo	...	...	.20	.93	.43	...	1.56	1.13
North Bridgton	...	...	.18	3.36	...	...	3.54	3.54
Old Town	.03	...	...	...	2.31	...	2.31	2.31
Portland	...	...	.01	.75	...	...	0.76	0.76
Presque Isle	.06	...	.06	.25	2.15	...	2.46	0.31
Ripogenus Dam	.00	.29	.26	2.76	.00	.00	3.31	3.31
Rockport (West)	...	...	...	...	1.41	...	1.41	1.41
Rumford	...	.05	.33	3.43	...	...	3.81	3.81
The Forks	.00	.02	.77	.79	1.85	.00	3.43	1.58
Upper Dam	...	...	...	...	...	...	4.52	...
Van Buren	.05	...	.15	.08	1.66	...	1.89	.23
Winslow	...	...	...	1.56	...	...	1.56	1.56
Woodland	...	...	.14	1.97	...	...	2.11	2.11

TABLE 5 (Continued).

RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

New Hampshire.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov. 2–5 Inc.	Nov. 2–4 Inc.
Berlin	.00	.00	.63	4.25	.96	.00	5.84	4.88
Bethlehem (a)	...	...	...	2.40	...	...	3.65	...
Bethlehem	...	...	*...	4.50	...	...	4.50	4.50
Claremont	...	...	...	...	...	...	4.65	...
Concord	...	.03	1.37	2.73	...	T.	4.13	4.13
Dummer	...	...	.48	2.70	...	...	3.18	3.18
Durham	...	...	...	2.76	...	...	2.76	2.76
Errol	...	...	...	...	...	...	3.27	...
Fitzwilliam	...	1.19	2.24	.33	...	...	3.76	3.76
Franklin	...	...	.60	5.42	...	.03	6.02	6.02
Garvin's Falls	...	.09	4.10	...	...	...	4.19	4.19
Glencliff	.00	.00	.95	4.70	.25	.00	5.90	5.65
Gorham	...	...	.74	4.21	1.26	...	6.21	4.95
Gregg's Falls	...	T.	4.51	.09	.02	...	4.62	4.60
Hanover	.00	.00	3.81	2.55	.00	T.	6.36	6.36
Keene	...	*...	1.70	2.87	...	.01	4.57	4.57
Lakeport	...	...	.35	3.71	...	.06	4.06	4.06
Lancaster	...	...	.65	1.70	.25	.03	2.60	2.35
Lincoln	...	.60	3.97	.47	.02	...	5.06	5.04
Littleton	...	...	...	...	...	...	4.42	...
Manchester	...	.02	2.88	...	...	...	2.90	2.90
Merrymeeting Lake	...	...	.13	3.95	...	...	4.08	4.08
Nashua (c)	...	...	.03	4.04	.02	...	4.09	4.07
Nashua (d)	...	...	*...	3.92	...	...	3.92	3.92
North Stratford	.01	...	1.02	2.20	.50	...	3.72	3.22
Pittsburg (e)	...	.86	2.70	.65	...	...	4.21	4.21
Pittsburg (f)	...	1.23	3.02	.96	...	...	5.21	5.21
Plymouth	...	.40	4.65	.25	...	...	5.30	5.30
Plymouth (h)	...	T.	.94	5.19	...	...	6.13	6.13
Pontocook Dam	...	...	...	...	...	...	3.18	...
Twin Mountain	...	*...	*...	4.74	...	...	...	...
West Stewartstown	.10	...	.98	1.86	.26	T.	3.10	2.84
Woodsville	...	...	.96	4.16	.05	.03	5.17	5.12

(a) New England Power Co.
(c) Pennichuck Water Works.
(d) Jackson Mills.
(e) First Connecticut Lake.
(f) Second Connecticut Lake.
(h) Weather Bureau.
*Precipitation included in following measurement.

TABLE 5 (Continued).

RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

Vermont.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2-5 Inc.	Nov.2-4 Inc.
Bellows Falls	.00	.00	.24	4.07	.18	.00	4.49	4.31
Bennington	...	...	*...	7.36	...	*...	7.36	7.36
Bloomfield	.01	...	1.02	2.20	.50	...	3.72	3.22
Brattleboro	...	.43	4.12	.12	.01	T.	4.68	4.67
Burlington	...	.52	3.75	1.35	T.	.15	5.62	5.62
Cavendish	...	...	4.92	3.04	.00	.01	7.96	7.96
Chelsea	...	...	2.83	4.52	...	...	7.35	7.35
Chittindon (a)	.00	1.65	6.60	.35	.00	.00	8.60	8.60
Cornwall	...	...	...	...	...	...	5.30	...
East Ryegate (b)	...	...	...	4.08	...	...	5.11	...
Enosburg Falls	.08	...	3.20	3.10	.05	.11	6.35	6.30
Garfield	...	...	4.07	3.87	...	.08	7.94	7.94
Middlebury	...	*...	2.00	2.80	...	...	4.80	4.80
Mollys Falls	...	...	...	...	...	...	9.14	...
Newfane	...	...	...	...	...	...	6.64	...
Northfield	...	...	6.17	2.46	.03	.08	8.66	8.63
Rutland (a)	...	1.90	6.12	.45	T.	.17	8.47	8.47
Searsburg (b)	.00	.00	.70	6.47	.03	.00	7.20	7.17
Searsburg Mt.	...	.00	.96	7.34	.17	...	8.47	8.30
Sherman	...	...	...	...	...	...	4.00	...
Silver Lake (a)	.00	.85	4.17	1.00	.49	.00	6.51	6.02
Somerset	.00	.00	.68	8.77	.20	.03	9.65	9.45
South Londonderry (b)	...	...	...	2.53	...	...	3.60	...
St. Johnsbury	.00	.00	1.00	5.39	.17	.02	6.56	6.39
Vernon (b)	.00	.00	.35	3.58	.18	.00	4.11	3.93
White River Junc. (b)	...	...	1.00	5.41	.18	.00	6.59	6.41
Whitingham (b)	.00	.00	.45	5.50	.06	.00	6.01	5.95
Wilder (b)	...	...	...	4.87	...	...	6.53	...
Woodstock	.00	.00	4.26	3.12	.00	...	7.38	7.38

*Precipitation included in following measurement.
(a) Vermont Hydro Electric Company.
(b) New England Power Company.

TABLE 5 (Continued).

RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

Massachusetts.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov. 2–5 Inc.	Nov. 2–4 Inc.
Adams (Incomplete) (A)	...	...	5.10	...	...	...	5.49	5.49
Amherst	...	.30	3.43	1.90	T.	...	5.63	5.63
Ashby	...	...	...	4.80	.07	...	4.87	4.80
Ashland	...	...	* ...	4.82	...	T.	4.82	4.82
Athol	.00	1.00	4.83	.09	.00	.00	5.92	5.92
Athol (b)	...	1.13	4.05	.04	T.	...	5.22	5.22
Attleboro	...	T.	2.25	...	...	T.	2.25	2.25
Baldwinville	...	.42	3.62	.39	...	...	4.43	4.43
Barre	...	.23	4.32	...	...	...	4.55	4.55
Beverly (c)	...	...	1.70	.64	...	.14	2.34	2.34
Blue Hill Observatory	...	...	.04	2.12	...	T.	2.16	2.16
Bondsville (Palmer)	...	.15	3.31	T.	T.	.02	3.46	3.46
Boston (W. B.)	.00	.00	.44	1.37	.00	T.	1.81	1.81
Boylston	...	* ...	* ...	6.77	...	...	6.77	6.77
Brockton	...	...	2.27	.07	...	T.	2.34	2.34
Cambridge	...	...	0.80	1.30	...	...	2.10	2.10
Charlton	...	.39	3.04	.01	...	...	3.44	3.44
Chester	...	.55	6.95	...	...	.03	7.50	7.50
Chesterfield	...	.41	6.20	.03	.02	...	6.66	6.64
Chestnut Hill	...	T.	2.24	.07	...	.02	2.31	2.31
Clinton	...	* ...	* ...	6.76	...	...	6.76	6.76
Colrain	...	.27	4.02	.40	...	...	4.69	4.69
Concord	.00	.00	T.	2.84	.00	T.	2.84	2.84
Cummington	.00	.33	5.70	.48	.01	T.	6.52	6.51
Dalton	...	...	2.00	4.51	...	...	6.51	6.51
Dana	...	* ...	4.15	.18	...	...	4.33	4.33
Dana (North)	...	* ...	* ...	4.97	...	...	4.97	4.97
Edgartown	...	...	1.40	.30	...	...	1.70	1.70
Egremont	...	...	6.10	.06	...	.11	6.16	6.16
Fall River (W. B.)	...	...	.45	1.81	...	...	2.26	2.26
Fall River (W. W.)	T.	...	.55	1.11	...	...	1.66	1.66
Falmouth	...	...	1.86	.05	...	...	1.91	1.91
Fitchburg	...	.05	5.12	.14	...	...	5.31	5.31
Framingham	...	...	* ...	4.60	...	.01	4.60	4.60
Franklin	...	.01	2.67	...	.00	.00	2.68	2.68
Gardner	...	...	4.06	.03	...	...	4.09	4.09
Gloucester	...	...	...	2.18	...	...	2.18	2.18
Granville (West)	...	...	* ...	6.70	...	...	6.70	6.70
Greenfield	...	.57	4.47	.02	...	...	5.06	5.06
Greenwich	...	.50	3.80	.04	...	.05	4.34	4.34
Groton	...	.02	6.67	.01	...	.01	6.70	6.70
Hardwick	...	.23	4.50	.05	...	T.	4.78	4.78
Haverhill	...	...	T.	2.14	...	...	2.14	2.14
Haverhill (B)	...	T.	2.19	.09	...	.01	2.28	2.28
Heath	...	.23	4.73	.24	...	...	5.20	5.20
Hingham (Town)	...	...	1.79	.60	...	...	2.39	2.39
Holyoke (W. B.)	...	...	1.21	3.73	...	...	4.94	4.94
Holyoke (1)	...	...	1.66	3.46	...	...	5.12	5.12
Holyoke (2)	...	...	1.72	3.31	...	...	5.03	5.03
Holyoke (3)	...	.04	1.63	3.43	...	...	5.10	5.10
Housatonic	...	.70	4.93	.08	...	...	5.71	5.71
Hubbardston	.01	.21	3.93	.02	.02	.01	4.18	4.16
Hubbardston (C)	...	.22	3.20	.04	...	T.	3.46	3.46
Huntington	...	.31	5.93	.04	...	...	6.28	6.28
Hyannis	...	1.15	.10	...	...	...	1.25	1.25

TABLE 5 (Continued).

Massachusetts (continued).

Cities and Towns.	November.						Totals.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Ipswich	...	...	1.96	.54	...	...	2.50	2.50
Jefferson	...	...	* ...	4.27	...	...	4.27	4.27
Lakeville	* ...	* ...	* ...	2.91	* ...	...	2.91	2.91
Lawrence	.00	.00	T.	2.30	.00	T.	2.30	2.30
Lawrence (D)	...	...	1.80	.18	...	.06	1.98	1.98
Leominster	.00	.00	.27	4.89	.00	.02	5.16	5.16
Lincoln (a)	...	...	2.17	T.	...	.02	2.17	2.17
Littleton	...	T.	6.32	T.	...	T.	6.32	6.32
Lowell	...	...	* ...	3.28	...	...	3.28	3.28
Ludlow	...	.66	3.58	...	...	.03	4.24	4.24
Lynn	...	.01	1.74	.34	...	.03	2.09	2.09
Manchester	...	...	1.37	.41	...	...	1.78	1.78
Mansfield	...	...	2.03	.02	T.	...	2.05	2.05
Mansfield (W. B.)	...	T.	.18	1.92	...	...	2.10	2.10
Marlborough	...	...	...	7.48	.19	...	7.67	7.48
Middleborough	...	...	2.62	.08	...	T.	2.70	2.70
Middlefield	...	.64	6.28	.08	T.	.05	7.00	7.00
Middleton	...	.01	2.00	.24	...	.05	2.25	2.25
Milford	...	...	2.95	3.41	...	...	6.36	6.36
Millbury (A)	...	...	6.50	...	...	...	6.50	6.50
Millis	...	...	.03	2.48	...	.02	2.51	2.51
Monroe Bridge (A)	.00	.00	.42	5.78	.10	.00	6.30	6.20
Monson	...	.24	4.00	.01	...	.02	4.25	4.25
Nantucket	.00	.00	.03	1.52	.00	T.	1.55	1.55
Natick (P)	...	...	.01	2.57	...	.02	2.58	2.58
New Bedford (E)	...	T.	2.84	.07	...	...	2.91	2.91
New Bedford (W. B.)	...	...	.51	1.35	...	...	1.86	1.86
New Salem	...	...	...	6.05	.05	...	6.10	6.05
Newburyport	...	...	2.05	.30	...	...	2.35	2.35
Newton	...	...	2.11	.04	...	.04	2.15	2.15
North Adams (F)	...	...	.83	4.93	.28	...	6.04	5.76
North Adams (G)	...	...	.57	6.93	.24	...	7.74	7.50
North Andover	T.	...	.02	2.60	.49	.02	3.11	2.62
Northbridge	...	T.	* ...	7.74	...	T.	7.74	7.74
Norwood	...	.01	2.30	.02	...	T.	2.33	2.33
Otis	...	...	.55	5.85	.15	...	6.55	6.40
Otis (West)	...	.10	7.35	.08	...	.08	7.53	7.53
Peabody (West)	.00	.03	2.28	.24	...	.05	2.55	2.55
Pelham	...	1.32	2.93	.14	...	...	4.39	4.39
Pembroke	...	...	1.91	...	...	T.	1.91	1.91
Peru	...	.38	5.55	.08	...	...	6.01	6.01
Petersham	...	* ...	* ...	2.09	...	...	2.09	2.09
Pittsfield	.00	.00	.85	4.86	.00	.00	5.71	5.71
Plainfield	...	.70	6.09	.04	.01	.01	6.84	6.83
Plymouth	...	.01	1.52	.03	...	...	1.56	1.56
Prescott	...	.93	4.12	...	...	...	5.05	5.05
Princeton	...	...	* ...	4.00	...	...	4.00	4.00
Provincetown	.02	...	...	1.40	...	...	1.40	1.40
Reading	...	.02	2.00	.03	...	.04	2.05	2.05
Rochester	...	...	2.51	.13	...	...	2.64	2.64
Rockport	...	...	* ...	1.14	...	...	1.14	1.14
Rutland (North)	...	.20	3.96	...	.03	.02	4.19	4.16
Rutland (West)	...	...	* ...	3.35	...	...	3.35	3.35
Salem	.00	T.	2.43	.29	.00	.01	2.72	2.72
Savoy	...	1.97	2.34	1.43	...	.04	5.74	5.74
Shelburne Falls (A)	.00	.00	.26	3.54	.02	...	3.82	3.80
Shutesbury	...	1.12	3.91	0.30	...	...	5.33	5.33

TABLE 5 (Continued).

Massachusetts (continued).

Cities and Towns.	November.						Totals.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Southampton (H)	...	...	3.18	2.67	...	...	5.85	5.85
Southborough (I)	...	...	T.	5.31	...	.01	5.31	5.31
Southborough (J)	...	...	*...	8.39	...	T.	8.39	8.39
Southbridge	.00	.51	3.35	.01	.00	.01	3.87	3.87
Spot Pond	...	.01	1.85	.15	...	.04	2.01	2.01
Springfield (K)	.00	1.00	...	3.06	.00	.00	4.06	4.06
Springfield (L)	...	.06	3.08	1.14	...	...	4.28	4.28
Springfield (M)	...	.47	6.16	.15	.08	...	6.86	6.78
Springfield (N)	...	.80	5.61	.03	.02	...	6.46	6.44
Springfield (O)	...	1.32	2.87	...	...	...	4.19	4.19
State Farm (Bridgewater)	...	T.	.63	...	...	...	0.63	0.63
Sterling	...	...	*...	4.57	...	...	4.57	4.57
Stockbridge	.00	.86	4.95	.10	.01	.24	5.92	5.91
Taunton	...	...	*...	2.60	...	...	2.60	2.60
Turners Falls	.00	.49	3.48	.49	...	...	4.46	4.46
Walpole	...	...	T.	2.10	.08	T.	2.18	2.10
Waltham (W. W.)	...	.01	2.36	...	...	.02	2.37	2.37
Ware	...	.17	4.12	.08	.01	...	4.38	4.37
Ware (West)	...	*...	*...	4.15	...	...	4.15	4.15
Wareham	...	...	1.70	.04	...	T.	1.74	1.74
Wareham (East)	...	...	T.	1.62	.05	...	1.67	1.62
Warren	...	.19	3.75	.06	...	.01	4.00	4.00
Warwick	...	1.37	2.08	.36	T.	T.	3.81	3.81
Webster	...	.22	3.70	T.	...	T.	3.92	3.92
Wendell	...	...	1.81	4.10	.12	.05	6.03	5.91
West Brookfield	...	.39	3.72	.03	...	...	4.14	4.14
West Roxbury (Q)	...	T.	T.	2.05	.01	...	2.06	2.05
Westfield	...	.80	3.90	...	...	.02	4.70	4.70
Westhampton (R)	...	...	2.23	2.45	...	...	4.68	4.68
Westminster (S)	...	...	...	4.30	...	...	4.30	4.30
Westminster (T)	...	...	...	4.12	...	...	4.12	4.12
Weston (U)	...	...	.01	2.48	...	...	2.49	2.49
Williamsburg	...	.48	4.07	...	...	...	4.55	4.55
Williamstown	...	...	5.08	1.07	.01	...	6.16	6.15
Winchendon	...	.91	3.80	.33	...	...	5.04	5.04
Wollaston	...	...	1.98	.12	...	.01	5.15	5.15
Worcester (S. W.)	...	...	.06	5.09	...	...	2.10	2.10
Worcester (W. W.) (V)	...	...	.19	3.92	...	...	4.11	4.11
Worcester (W)	...	...	.15	4.30	...	...	4.45	4.45
Worcester (X)	...	...	.31	4.19	.09	.06	4.50	4.50
Worcester (Y)	...	...	.20	4.79	...	T.	5.08	4.99
Worcester (Z)	...	...	.10	4.59	...	...	4.69	4.69
Worthington	..	.50	6.00	.02	.02	.02	6.54	6.52
Wrentham	.	.10	2.60	...	...	...	2.70	2.70

(W. B.) Weather Bureau
(W. W.) Water Works.
(S. W.) Sewage Works.
(1) Whiting Street.
(2) Ashley Ponds.
(3) High Service.
(a) Hobbs Brook Reservoir.
(b) Fryville.
(c) Wenham Lake.
(A) New England Power Company.
(B) Kenosa Lake.
(C) Williamsville.
(D) Experiment Station.
(E) L. J. Hathaway.
(F) Broad Brook.
(G) Notch Brook.
(H) Fomer Reservoir.
(Z) Clark University.
(I) Sudbury Dam.
(J) Cordaville.
(K) United States Arsenal.
(L) City Hall.
(M) Borden Brook.
(N) West Parish Filters
(O) Provin Mountain Reservoir.
(P) Lake Cochituate.
(Q) Brookline Pumping Station.
(R) White Reservoir.
(S) Wachusett Lake.
(T) Meetinghouse Pond.
(U) Stony Brook Reservoir.
(V) Lynde Brook.
(W) Holden Reservoir.
(X) Kettle Brook.
(Y) Kendall Reservoir.
*Precipitation included in following measurement.

TABLE 5 (Continued).
RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.
Rhode Island.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Block Island	...	T.	2.87	...	...	...	2.87	2.87
Fiskeville (a)	T.	.00	.01	4.83	.01	...	4.85	4.84
Hopkins Mills (a)	T.	.00	.07	7.85	.02	.00	7.94	7.92
Kent (a)	.00	.00	.11	7.51	.09	.00	7.71	7.62
Kingston	...	...	.48	2.50	...	...	2.98	2.98
Newport	...	...	...	...	...	...	1.68	...
North Scituate (a)	.02	.00	.03	6.80	.00	.00	6.83	6.83
Pawtucket (1)	...	...	.06	2.69	...	...	2.75	2.75
Pawtucket (2)	...	...	T.	2.77	...	...	2.77	2.77
Pawtucket (3)	...	T.	T.	2.24	...	...	2.24	2.24
Providence (4)	...	...	*...	2.57	...	...	2.57	2.57
Providence (5)	...	...	*...	2.20	...	...	2.20	2.20
Providence (6)	...	...	*...	2.26	...	...	2.26	2.26
Providence (7)	...	...	*...	2.95	...	...	2.95	2.95
Providence (8)	T.	...	*...	1.97	...	...	1.97	1.97
Providence (W. B.)	T.	T.	.52	.74	...	T.	1.26	1.26
Rocky Hill (a)	.02	.00	.02	6.86	.02	.00	6.90	6.88
Wakefield	.00	.00	.15	2.26	...	...	2.41	2.41
Westerly	...	...	*...	9.12	...	...	9.12	9.12
Westerly (W. W.)	...	...	*...	9.37	...	...	9.37	9.37
Woonsocket	...	...	...	4.20	.18	...	4.38	4.20

(a) Providence Water Supply.
(1) Diamond Hill; (2) Pumping Station No. 3; (3) Masonic Building; (4) Sockanosset Reservoir; (5) Pettaconset Reservoir; (6) Precipitation Plant; (7) Fruit Hill Reservoir; (8) Hope Reservoir.
*Precipitation included in following measurement.

TABLE 5 (Continued).
RAINFALL IN NEW ENGLAND — GREAT STORM OF NOVEMBER 3 AND 4, 1927.
Connecticut.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Bakersville (a)	...	...	*...	6.06	...	...	6.06	6.06
Barkhamsted (a)	...	...	*...	6.76	...	...	6.76	6.76
Bridgeport	.00	.01	3.09	0.73	.01	...	3.84	3.83
Colchester	...	*...	*...	4.21	.02	...	4.23	4.21
Hartford	...	.11	2.43	1.03	.01	...	3.58	3.57
Middletown	...	...	.39	3.29	...	...	3.68	3.68
Nepaug Dam (a)	...	...	*...	6.14	...	...	6.14	6.14
New Haven	...	.02	3.27	.51	.02	...	3.82	3.80
New London	...	...	.52	3.45	...	...	3.97	3.97
North Grosvenordale	...	...	.14	4.14	...	...	4.28	4.28
Norwalk	...	...	...	3.52	.05	...	3.57	3.52
Reservoir No. 4 (a)	...	*...	.71	3.27	...	...	3.98	3.98
Reservoir No. 6 (a)	...	*...	.56	3.46	.02	...	4.04	4.02
Storrs	...	.50	4.50	...	...	...	5.00	5.00
Thompsonville	...	...	.62	2.08	...	...	2.70	2.70
Waterbury	...	T.	2.91	2.21	.01	...	5.13	5.12
West Cornwall	.00	.03	2.45	2.85	.05	.04	5.38	5.33
West Hartland (a)	...	...	*...	6.64	...	...	6.64	6.64
West Hill (a)	...	...	*...	5.96	...	.16	5.96	5.96

(a) Hartford Water Works.
*Precipitation included in following measurement.

TABLE 5 (Continued).

RAINFALL IN NEW YORK — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Albany	.00	.05	3.28	.53	.01	T.	3.87	3.86
Bedford Hills	...	.02	1.70	1.55	...	...	3.27	3.27
Carmel	...	...	.39	2.52	...	.06	2.91	2.91
Chazy	...	...	1.75	.73	...	.05	2.48	2.48
Cutchogue	.00	.19	1.91	1.40	.03	.00	3.53	3.50
Dannemora	.00	.00	.85	1.10	.20	.20	2.15	1.95
Flushing	...	...	.19	2.08	.03	.03	2.30	2.27
Glens Falls	.00	.00	.35	3.10	...	...	3.45	3.45
Harkness	...	T.	1.70	1.21	...	.02	2.91	2.91
Mechanicville	...	...	1.28	4.27	.12	.07	5.67	5.55
New York City	...	.02	1.68	.15	.07	...	1.92	1.85
Roslyn	...	...	2.05	1.15	.09	...	3.29	3.20
Scarsdale	...	.30	2.10	1.17	.10	...	3.67	3.57
Setauket	...	...	2.58	.53	...	...	3.11	3.11
Spier Falls	...	...	2.18	.88	.02	...	3.08	3.06
Wappingers Falls	.00	T.	3.32	1.43	.04	.00	4.79	4.75
West Point	.00	.96	4.14	.17	.07	.00	5.34	5.27
Yonkers	.00	.00	2.22	.38	.13	...	2.73	2.60

TABLE 5 (Concluded).

RAINFALL IN CANADA — GREAT STORM OF NOVEMBER 3 AND 4, 1927.

CITIES AND TOWNS.	NOVEMBER.						TOTALS.	
	1	2	3	4	5	6	Nov.2–5 Inc.	Nov.2–4 Inc.
Brome	...	...	1.45	2.02	.39	...	3.86	3.47
Drummondville	...	...	2.35	3.49	...	...	5.84	5.84
East Angus	...	...	.56	2.62	.30	...	3.48	3.18
Farnham	...	...	1.92	2.67	.02	.14	4.61	4.59
Lambton	.40	.55	.25	.40	...	...	1.20	1.20
Lennoxville	...	...	2.29	2.40	...	...	4.69	4.69
Megantic	...	*...	.58	1.75	...	...	2.33	2.33
Montreal	...	...	...	...	...	...	2.50	...
Nicolet	...	...	.53	4.50	...	...	5.03	5.03
Quebec	...	...	...	...	...	...	2.02	2.02
Sherbrooke	...	.01	3.11	1.92	.01	...	5.05	5.04

*Precipitation included in following measurement.

TABLE 6.

HOURLY RAINFALL TAKEN FROM THE RECORDS OF RECORDING GAGES DURING THE GREAT STORM OF NOVEMBER 3 AND 4, 1927.

Date	A.M.												P.M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Albany, N. Y.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	T	.05	T
3	.01	.03	.03	.04	.25	.09	.16	.14	.25	.30	.18	.31	.27	.18	.12	.25	.08	.13	.12	.16	.05	T	.01	.12
4	.15	.05	.07	.05	.03	.03	.05	.05	T	T	.04	.01	T	...	...	...	...	...	...	...	...	...	...	...
Blue Hill Observatory.																								
3	...	...	...	...	T	T	T	...	...	...	...	...	...	...	...	...	...	...	.02	.02	.05	.11	.26	.40
4	.46	.17	.05	.04	.12	.19	.15	.07	.02	.01	.01	.01	...	...	...	...	...	...	...	...	...	...	...	...
Boston Mass. Weather Bureau.																								
3	...	T	...	...	T	T	...	...	...	...	...	...	...	...	...	...	...	...	...	T	.01	.01	.09	.33
4	.28	.15	.41	.09	.07	.11	.04	.15	.07	T	T	T	T	...	...	...	...	...	...	...	...	...	...	...
Brookline, Mass.																								
3	....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.01	...	.07	.20
4	.28	.16	.26	.10	.06	.10	.04	.04	.01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
*Burlington, Conn. (Phelps Brook Dam).**																								
3	...	...	.16	.04	.18	.08	.02	.00	.01	.02	.01	.05	.38	.01	.05	.08	.28	.03	.23	.50	.29	.35	.34	.37
4	.20	.05	.27	.16	.42	.32	.06	.04	.05	.28	.18	...	...	...	...	...	...	...	...	...	...	...	...	...
Concord, N. H.																								
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.12	.39	.80
4	.43	.62	.34	.66	.26	.31	.05	.04	.01	T	.01	T	...	...	...	...	...	...	...	...	...	...	...	...
Eastport, Maine.																								
4	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.01	.46	.77	.51	.71	.32	.15
5	.12	.06	.03	T	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Hartford, Conn.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	T	...	...	...	...	...	T	T	T	.01	T	.10
3	.01	.01	.03	.03	.06	.09	.01	T	T	T	T	.08	.10	.05	.01	.04	.10	.16	.44	.25	.27	.20	.26	.23
4	.25	.34	.08	.05	T	.14	.15	.02	...	T	T	...	...	...	...	...	...	...	...	...	...	...	...	...

TABLE 6 (*Continued*).

HOURLY RAINFALL TAKEN FROM THE RECORDS OF RECORDING GAGES DURING THE GREAT STORM OF NOVEMBER 3 AND 4, 1927.

Date	A.M.												P.M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Lowell, Mass.																								
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.01	.05	.20	1.04
4	.53	.37	.67	.15	.07	.09	.07	.01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Montreal, Que.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.02	.05	.04	.03	.04	.06	.12	.07	.05
3	.04	.07	.01	.03	.06	.02	.01	.00	.02	T	.07	.02	.03	.11	.06	.09	.08	.11	.12	.11	.02	.06	.16	.13
4	.09	.02	.03	.09	.06	.06	.06	.03	.02	.02	.04	.03	.02	T	.01	T	.01	...	...	...	...	...	...	...
New Haven, Conn.																								
3	T	.00	.03	.06	.02	.00	.05	.02	T	.00	T	.02	.08	.12	.24	.25	.30	.53	.27	.39	.06	.25	.30	.28
4	.22	.07	.06	.01	.13	.01	.01	...	...	T	T	...	T	...	...	...	...	...	...	...	...	...	...	...
New York, N. Y.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	T	.01	...	.01	...	...	...	T	...	...	...	...
3	...	...	T	.04	.15	.02	T	T	.03	.09	.27	.03	.01	.15	.25	.19	.04	.27	.04	T	...	.05	.05	T
4	T	T	T	T	.01	.02	.02	.06	.03	.01	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Northfield, Vt.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.02	.20	.01
3	.03	.01	T	.04	.43	.29	.20	.14	.30	.15	.14	.45	.51	.54	.57	.62	.51	.31	.35	.38	.14	.35	.43	.24
4	.18	.16	.21	.11	.11	.10	.04	.02	.14	.15	.03	T	T	T	.02	T	...	...	...	...	...	...	...	...
Pawtucket, R. I.																								
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.01	.04	.14	.31	.14	.33
4	.35	.30	.21	.09	.08	.08	.03	.13	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Portland, Me.																								
3	...	...	T	.01	T	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
4	...	...	...	.02	.03	.25	.23	.03	.02	T	.02	.11	T	.04	...	...	...	...	...	...	...	...	...	...
Providence, R. I.																								
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	T	.02	.08	.12	.07	.23
4	.12	.16	.16	.06	.07	.06	.03	.08	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

Date	A.M.												P.M.											
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Providence, R. I. (Hope Reservoir).																								
3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.05	.11	.10	.07
4	.12	.32	.20	.27	.05	.07	.10	.06	.04	.01	T	...	...	...	...	...	...	...	...	...	...	...	...	...
Springfield, Mass.																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.00	.01	.03	.02
3	.04	.15	.06	.04	.07	.12	T	.00	T	.01	.00	.04	.24	.11	.06	.00	.02	.19	.29	.55	.28	.24	.28	.29
4	.18	.33	.11	.06	.02	.04	.35	.04	.00	.00	T	.01	...	...	...	...	...	...	...	...	...	...	...	...
*West Hartford, Conn. (West Hartford Filters).**																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.03	.01	.11
3	.02	.04	.01	.10	.06	.03	.04	.00	.01	.00	.02	.09	.05	.06	.12	.14	.27	.35	.23	.30	.24	.10	.28	.22
4	.32	.31	.04	.04	.03	.12	.11	.01	.01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Worcester, Mass. (Winter Hill Observatory).																								
2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.06	.02	T
3	T	...	...	...	...	...	.04	.02	...	...	...	...	...	...	...	.05	.00	.00	T	.09	.26	.68	.24	.59
4	1.26	.35	.21	.32	.07	.01	.02	.11	T	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Worcester, Mass. (Sewage Treatment Plant).																								
3	...	...	...	...	...	...	.06	...	...	...	...	...	...	...	.03	.01	.01	.01	T	.07	.39	.60	.88	1.42
4	1.19	.10	.23	.09	.01	T	.02	.03	.01	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...

*Hartford Water Works.

TABLE 7.

RAINFALL INTENSITIES FOR VARIOUS PERIODS OF TIME FROM RECORDING GAGE RECORDS.

	Minutes.				Hours.		
	5	10	15	30	1	2	24
Albany, N. Y.	.07	...	.13	.22	.32	.63	3.49
Block Island	.16	...	.34	.57	.84	1.40	2.87
Blue Hill Observatory	.07	...	.17	.30	.51	1.07	2.16
Boston, Mass.	.09	...	.14	.27	.41	.58	1.81
Brookline, Mass.	.05	...	.11	.20	.33	.45	1.54*
Burlington, Vt.	.07	...	.15	.26	.46	.76	4.50
Concord, N. H.	.11	...	.38	.56	.85	1.37	4.04
Eastport, Me.	.17	...	.39	.52	.77	1.40	3.14
Hartford, Conn.	.11	...	.20	.33	.46	.63	3.22
Lowell, Mass.	.20	...	.44	.72	1.20	1.73	3.26*
Montreal, Que.	.03	...	.07	.12	.16	.29	1.64
Nantucket, Mass.	.14	...	.24	.39	.70	.99	1.55
New Haven, Conn.	.13	...	.28	.40	.59	.84	3.67
New York City	.16	...	.23	.27	.30	.47	1.68
Northfield, Vt.	.15	.19	.23	.42	.69	1.22	3.58
Pawtucket, R. I.	.06	...	.16	.26	.41	.66	2.24
Portland, Me.	.05	...	.08	.14	.25	.48	.75
Providence, R. I.	.06	...	.09	.17	.24	.37	1.26
Providence (Hope Reservoir)	.08	...	.13	.21	.32	.52	1.97*
Springfield	.09	...	.27	.41	.55	.83	3.08
Worcester (Winter Hill)	.27	...	.66	.73	1.26	1.87	4.92*
Worcester (Sewage Works)	.30	...	.61	1.04	1.65	2.60	5.07

INTENSITIES FOR 2 AND 24 CONSECUTIVE HOURS FROM POWER STATION RECORDS FURNISHED BY THE NEW ENGLAND POWER COMPANY.

Monroe (Bridge)	.78	5.78
Searsburg, Vt.	1.17	6.47
Shelburne Falls	.49	3.54
Somerset, Vt.	1.31	8.77
Vernon, Vt.	.80	3.58
Whitingham, Vt.	.81	5.14
Whitingham, Vt. (Davis Bridge Dam)	.71	5.50

*Twenty-four-hour period by stick measurement.

Discussion.

C. W. Mowry.* Aside from the direct property damage and the meteorological interest in rainfall and run-off, there were many other lessons that water-works engineers could learn from the storm of November 3–4, 1927.

Public water supplies in many towns were crippled temporarily when bridges supporting street mains were carried away, when mains crossing river beds were undermined or broken by flood-carried boulders, when wash-outs exposed and broke street mains, or when pumping stations were flooded. Water-department men worked feverishly day and night to repair the breaks and to restore water service for sanitary purposes and for fire protection after the interruptions, which varied from a few hours to a few weeks.

North Adams suffered seriously. Eight-inch, 12-in. and 16-in. mains crossing the river on bridges were wrecked, and 10-in. and 14-in. mains crossing on the bed of the river were broken. At Woonsocket, a 12-in. main crossing a bridge was deliberately broken by the Water Department for fear the bridge would be carried away and would break off the main back of the valve so that the water could not be shut off. By first shutting the valves and then breaking the pipe in between, this possibility was avoided. The experience, however, points out the desirability of locating gate valves well back from the bank and then anchoring the pipe securely by a concrete pier between the valve and river bank, as protection for the control valves.

In St. Johnsbury, Vt., an 8-in. and a 14-in. pipe laid on the bank of the Passumpsic River were broken. A 10-in. by-pass of steel spiral riveted pipe laid on the up-stream side of the bridge for use in case of the failure of the 14-in. pipe, was found worthless due to corrosion. At the present time, an 8-in. cast-iron pipe is being laid across the river on the ice. When all the lead joints are poured, it is the intention to cut an opening in the ice and lower the pipe to the bed of the river. To replace the 14-in. pipe, a special bridge is to be built. All of this work will take from two to three months.

These various experiences are also important from the fire-protection standpoint, because many valuable properties were left entirely without fire protection. Fortunately, no fires occurred, but the fire pumps which maintained pressure on the sprinklers throughout the interruption of public supplies, gave a good demonstration of the value of a secondary water supply for valuable properties.

*Assistant Manager Inspection Department, Factory Mutual Fire Insurance Companies.

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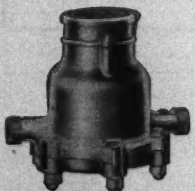
Corrosion is the worst foe of most metals. Only a few can resist — and they are costly. Platinum, for instance, is used at enormous expense to preserve for generations to come the accuracy of the nation's standard weights at Washington. Tin — almost a semi-precious metal now — like platinum resists the corrosive elements. Its use to prevent corrosion is a sign of quality construction.

Science has found a way to overcome Corrosion

TO protect against corrosion, Hersey uses the most expensive method employed in the manufacture of water meters — dipped tinning. Water ever present cannot corrode this thick coating of tin.

Clogged meters are easily cleaned if dip-tinned, leaving a surface as smooth and clean as new. Clean meters are more accurate. Because Hersey Water Meters are corrosion-proof and easily cleaned they have an accurate life that is ten to fifteen years longer than ordinary water meters.

For longer life, greater accuracy, and *more* revenue — insist on Hersey Water Meters. They give the *least* trouble and the *best* service.



Strength, Balance, Sensitivity and Dip-tinned — these are Hersey features that save money.

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WATER METERS

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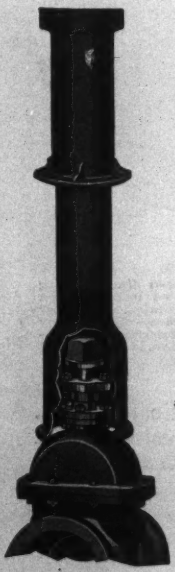
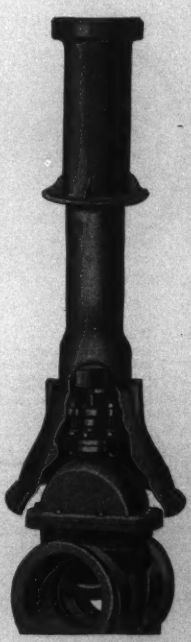
BINGHAM & TAYLOR'S Sliding Type Service and Valve Boxes are meeting with the approval of many New England Waterworks officials.



The cuts shown are our two and three piece sliding type adjustable valve boxes.

We carry a complete stock on hand at all times.

Wire, phone or write us when you are in a hurry for a shipment.



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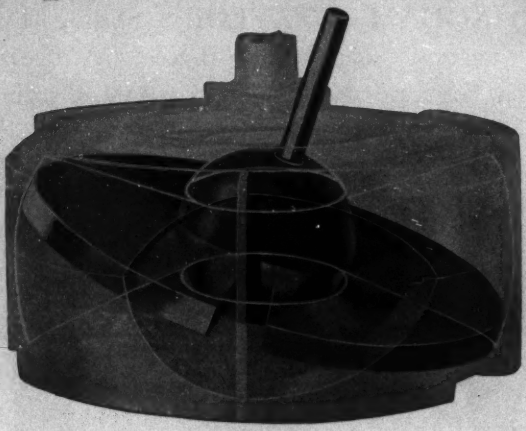
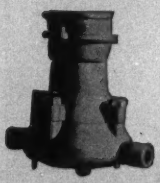


Water Out
Entire water content of measuring chamber passing from inlet to outlet causes one complete disc movement ("nutation") and consequently one revolution of projecting spindle.

THE SYMBOL OF SUSTAINED ACCURACY

Water In
Water enters disc measuring chamber on inlet side of a radial partition, its passage through chamber causing disc to move positively and projecting spindle to revolve.

Simple. Positive. Sensitive. No complicated parts. Water cannot pass through without causing perfect operation. Ask experienced water works men everywhere.



Pioneers in Meter Progress—
Yesterday, TODAY, Tomorrow

NEPTUNE METER CO.
THOMPSON METER CORP.
50 EAST 42ND STREET
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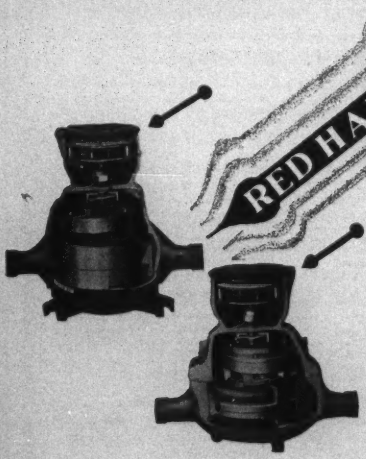
"Cash Registers of the Water Works Field"

NO. 4

WATCH FOR NO. 5

INSIDE INFORMATION

Large Red Test Hand



THE large red test hand is of inestimable value in testing meters since its speed of travel and long sweep (one revolution for each ten gallons) makes it a simple matter to check for inaccuracies when testing meters, either on the premises or in the shop. The reading of the large hand can be accurately made while meters embodying only the small test circle cannot be checked to such an accurate degree.

Another feature of the large test hand is the ease with which leaks are detected. Close all spigots and watch the large red hand. If it moves there is positive proof that water is leaking somewhere on the premises.

Pittsburgh Equitable Meter Co.

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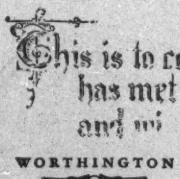

TEST data developed and presented by equipment manufacturers are generally accepted as reliable, and justly so. However, when tests are conducted and certified by disinterested engineers outside the organization responsible for the equipment tested, the results take on an added interest and significance.

Following are the findings in three such efficiency tests of Worthington Centrifugal Pumps:

Testing Engineers: Ford, Bacon and Davis, Inc., New York, N. Y.
Equipment: 4-inch, 3-stage, horizontal centrifugal oil line pump (usually operated two in series)
Service: Pumping crude oil with a viscosity of 120 S. U. S., 23.2 A. P. I. gravity, at rate of 31,500 bbl. per day, at 395 lb. pressure; operating at 3577 r.p.m.
Efficiency: 76.3%

Testing Engineer: Prof. Charles M. Allen, Worcester Polytechnic Institute
Equipment: Two 54-inch, single-stage, vertical centrifugal pumps
Service: Pumping river water at Rocky River Plant of Connecticut Light and Power Co., at rate of 571.6 cu. ft. per sec., against 229.67 ft. dynamic head; 16,216 shaft h.p.; operating at 327 r.p.m.
Efficiency: 91.9%

Testing Engineer: Mr. William C. Rudd, Assistant Engineer of Power, Detroit Department of Water Supply
Equipment: Two 36-inch, single-stage horizontal centrifugal pumps
Service: Pumping Detroit water supply. One at rate of 50,000,000 gal. per 24 hr. against 174.29 ft. head; one rate of 70,000,000 gal. per 24 hr., against 173.89 ft. head; operating at 514 r. p. m.
Efficiencies: 88.5% and 86% respectively

The organization that can design and build efficient pumps for such installations as these can render a useful service in the solution of *your* pumping problems. *Call our nearest district sales office for a Worthington engineer.*

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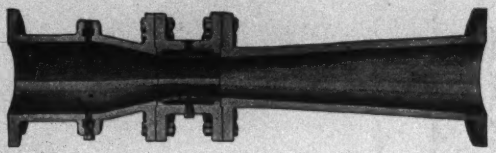

The Venturi Tube

In 1891 the Venturi Tube was new. Those Engineers who knew of it hoped it would help solve the difficult problem of measuring the flow of water in large pipe lines.

In 1929 the Venturi Tube is accepted by Engineers as the most dependable and accurate means of measuring flow through pipe lines.

It may be worthwhile, however, to summarize a few of the important advantages of the Venturi Tube:

1. The flow is guided at all points.
2. The inlet and throat pressures are taken off at definitely fixed points; the annular pressure chambers assure the use of true average pressures.
3. The Venturi throat is accurately centered in relation to the rest of the pipe line.
4. The friction loss through a Venturi Tube is the lowest of any differential producer. The Venturi Meter, then, operates on a greater differential with less friction loss, and is a more powerful instrument with a wider measuring range than other meters.
5. The coefficients of the Venturi Tube have been definitely established in numerous calibration tests of tubes ranging in size from 1 inch to 8 feet in diameter.

VENTURI
"VENTURI" Registered

BUILDERS IRON FOUNDRY

"Builders of the Venturi since 1891"

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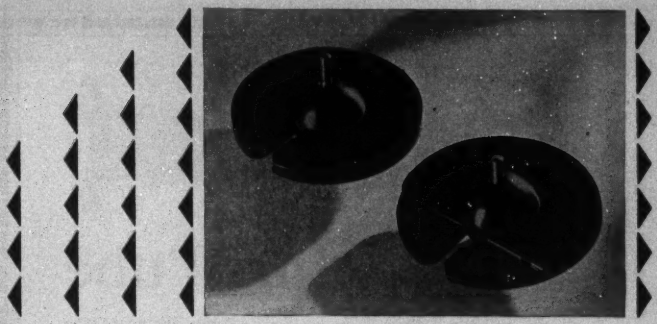


Extra thickness in these sturdy discs

THICKER perhaps than could be "gotten by with" but no thicker than necessary, the sturdy discs used in Niagara and American Water Meters assure accurate, smooth, quiet operation of the meter under all conditions.

A meter is only as good as its component parts, and that's the reason for the care and precision used in the manufacture of the disc used in Buffalo-Made Water Meters. The following are the reasons why these discs continue their day in and day out service for years and years:

1. **Thickness.** The added thickness found in the disc gives a liquid seal that prevents water slippage. This added thickness means longer life.
2. **Sensitivity.** The thicker disc is more sensitive to the flow of water thru the meter, thus the meter measures more accurately.
3. **Sturdiness.** The disc is carefully reinforced with a perforated aluminum alloy reinforcing plate. This prevents the disc from breaking under any unusual service conditions.
4. **Balance.** The flat type disc is inherently in balance—thus assuring longer life and unfailing accuracy of the meter.

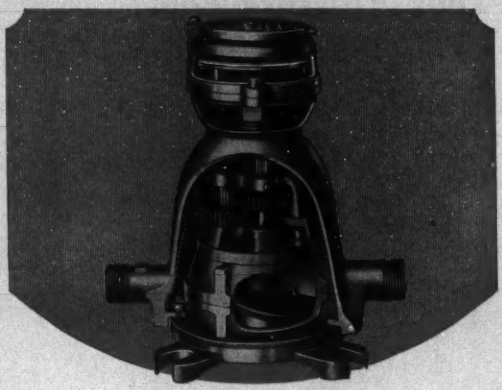
The disc used in Niagara and American Water Meters is moulded of hard rubber. Hard rubber is non-corrosive and buoyant. It is carefully machined twice with diamond tools to a precision tolerance of .001". On endurance tests the disc has run for months at a speed of fifteen movements per second without appreciable wear.

A great many years of study was necessary to the perfection of Niagara and American Water Meters — years of trial which assure you in advance that the tax payers' dollar will be a dollar invested in a lifetime of service and satisfaction.

Specify Niagara and American Water Meters when your municipality is in the market. There will be no regrets in the years to come.

Buffalo Meter Co., 2896 Main St., Buffalo, N. Y.

NIAGARA *and* AMERICAN
IRON CASE BRONZE CASE
Water Meters



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It has taken sixty years' experience to build water meters the UNION way.

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Water Meters - Easy Turning Stops - Chronometer Valves
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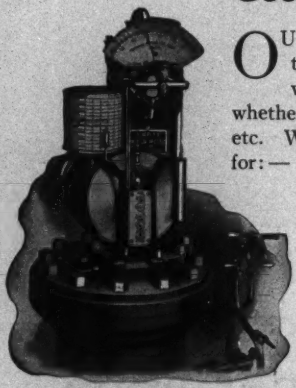
Are You Short on Pumping Capacity?
Do You Know Where Your Water Goes?



OUR Engineering Department will tell you how to determine your water distribution, how to find out whether or not new mains are required, etc. We can supply you with the means for:—

1. Checking up pump performance and determining slippage due to leaky plungers, defective valves, short stroking or other causes,
2. Measuring delivery of centrifugal pumps and figuring whether or not the station is up to efficiency,
3. Distributing proportionately the cost of water supplied to several districts,
4. Checking up the performance of filter beds,
5. Detecting waste or pipe leakage,
6. Recording daily amounts of sewage handled and planning future extensions, etc., etc.

THE SIMPLEX METER

VENTURI, PITOT TUBE OR ORIFICE TYPES

THE importance of exact measurements by means of a Simplex Meter cannot be over emphasized. Mr. Jeffries, Chairman of the West Chester, Pa. Water Works Committee, was able, by checking the performance of his pumping engine with a Simplex Meter, to discover that due to the imperfection and wear in the valves the slippage amounted to 300,000 gallons of water per day. This represented a daily loss of $30.00, or in other words a daily saving of $30.00, or $900.00 per month, when the valves were put in order. The Simplex Meter thus paid for itself in a month's time.

Frequent repeat orders from satisfied customers who formerly used other meters are the best evidence of merit of the Simplex Meter.

We have had many years' experience in solving water flow problems involving all sorts of conditions, and we are at all times prepared to submit general layouts involving cost and capacity, and to make explicit and complete recommendations. Write for Bulletin N26.

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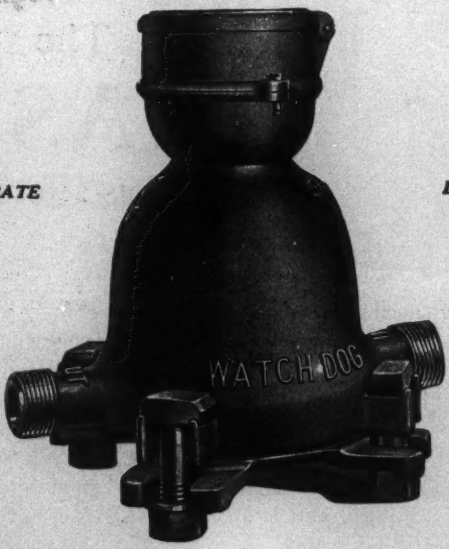
"WATCH DOG" WATER METERS

ACCURATE *DURABLE*



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Inquiries Solicited

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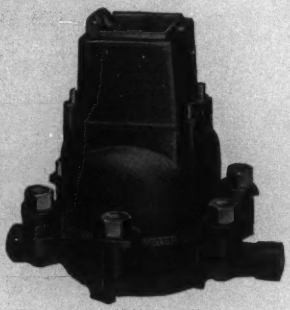
METERS



The NASH

A DISC METER

We have been making disc meters for over forty years. In fact, our Engineer, Lewis H. Nash, was the first in this country to perfect the nutating disc principle as a water measuring device. The first breakable frost base ever used on a meter was on our NASH of 1888. The NASH also had the first reinforced conical disc. The NASH has been a leader since its first appearance, and is still the best disc meter at any price.

The NASH is an all bronze meter, with every worth while modern improvement. It is accurate, strong, and thoroughly reliable in every particular. Made in both frost and non-frost models.

Let us send you fully descriptive NASH circular. Ask for No. 204.

NATIONAL METER COMPANY

299 Broadway, New York

New England Branch, 287 Atlantic Ave., Boston, Mass.

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WHAT is a Water Meter's Work?

It is that of a silent guardian continuously on duty — 24 hours daily, every week, month, and throughout the years. It must be accurate, measuring for you the dollars expended for water, distributing lines, pumps, power or fuel.

Regardless of capacity demand, climatic changes or water conditions, it is essentially a guardian of your possible earnings on invested capital.

No better guardian has yet been developed than a Badger Water Meter.

May we send you detailed Bulletin?

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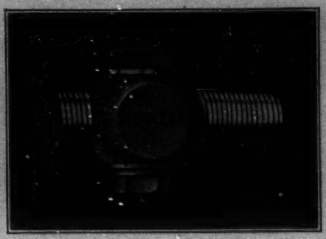
BADGER Water METERS



MUELLER Corporation Stop G-1C001

Service you can rely upon

Each MUELLER Stop is built as a unit!

THE key is ground into its own body — special grinding compounds and methods insure a smooth, leak-proof surface. Key and stop are never made separately and then assembled! Add to this the fact that all MUELLER bronze wear is made only from virgin metal and you will realize why better than 85% of water works specify MUELLER by name.

The design shown above is for wipe joints. The one below, for lead flange joints which provide a perfect connection without the inconvenience and expense of wiping.

All MUELLER bronze wear is produced to laboratory control of copper content—insuring a non-porous texture of great fineness. Let us send you full particulars — MUELLER quality means lower costs in the long run.

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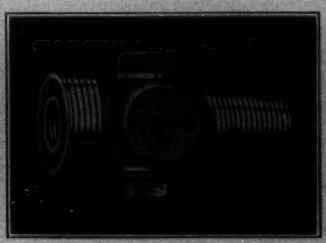

MUELLER Corporation Stop G-10002

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CORPORATION STOPS *for* MUELLER Tapping Machines

ATTENTION
WATER WORKS
OF NEW ENGLAND

A few reasons why we solicit your inquiries on Water-Works Pumping Equipment:

First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

Second. — Total responsibility of installation is assumed by us.

Third. — We relieve the purchaser of every detail and turn the complete unit over to him under actual operation and with guarantee.

Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.

Remodeled Pumping Station at Bridgewater, Mass., completely installed by F. A. Mazzur Co., Inc. Barbour & Dixon, Eng'r's.

F. A. Mazzur Co., Inc.
141 MILK STREET, BOSTON

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MINERALEAD

The Most Satisfactory Jointing Material for Bell and Spigot Water Pipe

Because

From the engineer's viewpoint:
It insures permanent tight joints at a minimum cost.

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Its greater convenience means faster work and more profit.

Manufactured by

The Atlas Mineral Products Company
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Manufacturers of G-K Sewer Joint Compound, the original bituminous joint for terra cotta pipe.

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INCORPORATED

Engineers and Contractors for
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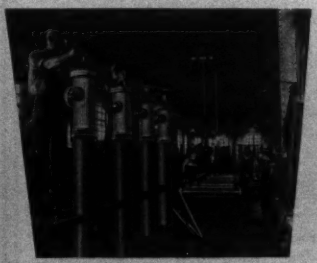

O'BRIEN HYDRANTS
Undergo Many Inspections

THE illustration shows the famous O'Brien Hydrants undergoing final tests under pressure before final approval. This is the last of a long series of such tests during the processes of manufacture which involves a considerable amount of work and expense. However, we know that only in this manner can the high standards of the cities in which these hydrants are today standard be surely met.

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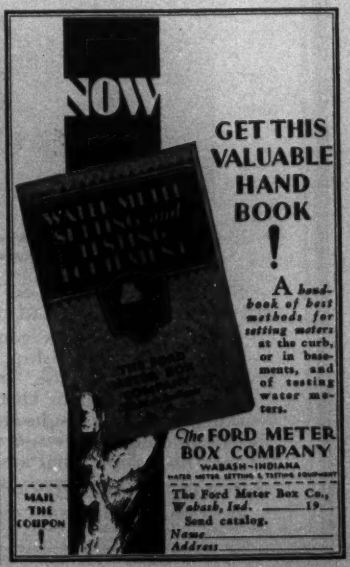
WATER WORKS SPECIALTIES & SUPPLIES
A.P.S. 1928
THE A.P. SMITH MFG. CO. *East Orange, N.J.*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GET THIS VALUABLE HAND BOOK !
A *hand-book of best methods for setting meters* at the curb, or in basements, and of testing water meters.
The FORD METER BOX COMPANY
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MAIL THE COUPON !
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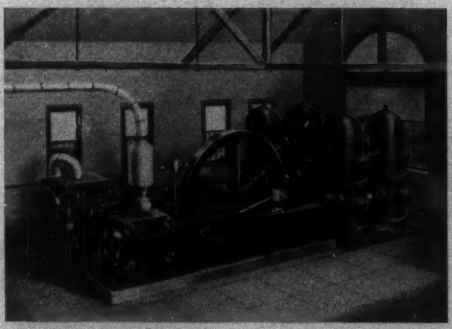
BURLINGTON, IOWA, U. S. A.

Builders of High Duty Pumping Engines

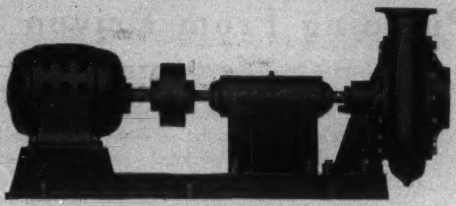


Murray High Duty Crank and Fly Wheel Pumping Engine, Opposed Type

STARKWEATHER & BROADHURST, INC.,
79 MILK STREET, BOSTON

will be glad to show you the superior design and excellent workmanship of the new 3 M. G. D. Murray Pump in the Arlington Pumping Station of the Metropolitan District Commission. Exceptional operating results are being obtained as shown by the official duty test which exceeded the guaranty by a substantial amount.

PLEASE SEND US YOUR SPECIFICATIONS AND CALLS FOR BIDS



Fairbanks-Morse Horizontal Trash Pump direct-connected to Fairbanks-Morse Ball-Bearing Motor

Now a great advance in sewage pumping

For the first time a pump has been designed that will handle fluids containing the fibrous and stringy matter found in sewage — without clogging, without preliminary screening, and without the excessive power consumption that characterizes the less satisfactory open impeller type of pump.

The secret of this pump's success lies in the design of the simple two-blade impeller. The blades of the impeller have well-rounded entering ends and are well filleted with the shrouds or sides. Thus a rag or other trash does not find sharp projections on which to catch and cause clogging. Since the impeller is the enclosed type, foreign matter, in passing through, does not come into contact with stationary side plates, but is promptly discharged through one of the large ports into the pump case. In this way power is conserved and efficiency increased.

This pump was designed by Mr. A. B. Wood who has been serving the city of New Orleans and other municipalities in the capacity of consulting engineer. It was originated by Mr. Wood to cope with the very unusual sewage problems found in New Orleans and met with immediate success.

Fairbanks-Morse Trash Pumps are made in two types, horizontal and vertical. They are ruggedly built to cope with severe service and at the same time they possess such refinements as ball bearings, smoothed fluid passages, and other marks of quality construction.

Ask for bulletins giving complete details.

FAIRBANKS, MORSE & CO., Chicago

28 branches in principal cities at your service.

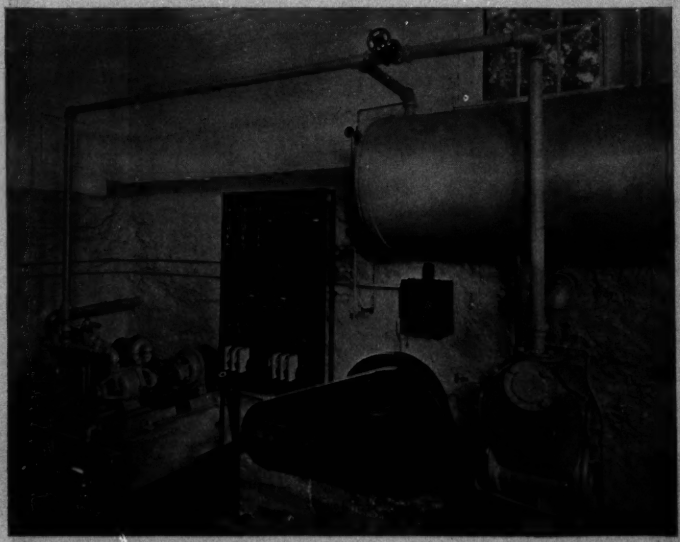
FAIRBANKS-MORSE

PUMPS · DIESEL ENGINES · MOTORS

DE LAVAL CENTRIFUGAL PUMPS

For Pumping From Driven Wells

BY the use of our automatic priming system, any number of such wells can be pumped by our De Laval Centrifugal Pumps even when in the dry season a considerable suction lift exists. The illustration below shows two motor driven vacuum priming pumps with automatic control panel and vacuum tank serving two sand chambers from which multistage centrifugal water works pumps take their suction. Each sand chamber takes its supply from fifty—2½" driven wells.



The reciprocating pump in the foreground was already in the plant and is now connected as a standby only.

This system continuously removes all air entering with the water and the station becomes fully automatic in operation without any danger of pumps starting up without priming or losing their priming due to unusual air leakage.

TURBINE EQUIPMENT CO. OF NEW ENGLAND

80 Federal St., Boston, Mass. **Phone LIBerty 5993**

Engineers and Contractors for complete De Laval Waterworks Pumping Equipment

Write us for full details and specifications.

High Waters of the Mississippi River in Louisiana

SPRINGTIME is FLOOD TIME

Continuous Chlorination

Will Safeguard Your Water Supply

"The Only Safe Water is a Sterilized Water"

Every Spring "old man river" starts his annual rampage—dealing death and destruction to the unprepared. With the first thaws of Spring comes his warning! . . . Will you be ready?

Will you be ready to overcome the gross pollution that the flood will bring to your water supply?

Will you be ready with W. & T. apparatus and Liquid Chlorine to destroy the microbes of disease and eliminate the danger of water-borne epidemics?

W. & T. are ready! . . . Why wait for the flood.

WALLACE & TIERNAN CO., Inc.

Manufacturers of Chlorine Control Apparatus

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NEWARK, NEWJERSEY

H-6

Biggs Electrically Welded Steel Pipe is Manufactured Under Procedure Control, Insuring a *Uniform* Product

This illustration shows a Biggs automatically welded pipe section of 1/2″ steel plate, 48″ in diameter and 10 feet long, being subjected to 1000 pounds' hydrostatic pressure. The test is being witnessed by Inspectors Conard, Anderson and Marshall, representing the cities of Boston, Detroit and Philadelphia, respectively. ¶During the test the 1-1/4″ thick concave head completely reversed itself. The pipe shell was materially distorted, but the automatic electrically welded seams held perfectly — they never even sweat. The section was afterward subjected to 1250 pounds' pressure in an attempt to test the pipe to destruction, but with the same gratifying result. ¶Biggs Electrically Welded Steel Pipe, 30″ to 72″ diameter, is in service on numerous important municipal water works projects. We should be pleased to discuss your present or pending requirements. Literature upon request.

THE BIGGS BOILER WORKS COMPANY

(30″ and larger steel pipe, welded or riveted)

Seneca and Kent, Akron, Ohio

New York Chicago Detroit

BIGGS Steel Pipe *Riveted and Welded*

The Biggs Boiler Works Co. Akron Ohio

PRECALKED JOINT PIPE

CAST IRON PIPE

Bell and Spigot—Sand Cast—Modern Weights

Sizes: 1¼ through 12 inches. Lengths to 16 feet

Boston stocks. Furnished with or without Precalked Joints

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General Offices: BIRMINGHAM, ALA. Foundries: BIRMINGHAM, ALA., PROVO, UTAH

Main's Hotcoating for the inside of standpipes and water tanks, will stop all pitting and corroding, and is guaranteed for seven years.

Also

Main's Coverall Salt Air Paint, for the outside of standpipes and water tanks, guaranteed for four years.

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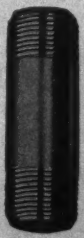
RED BRASS NIPPLES

Standard and Extra Heavy
85% Copper Content Guaranteed



Diameters from 3/8" to 4" inclusive.
In stock, ready for 24-hour shipment.

Order through your Jobber, or write us direct for name of nearest distributor.

WARE COUPLING & NIPPLE CO.
WARE, MASS., U. S. A.

Corrosion of Iron and Steel Water Pipes

Information on this subject is desired by the Committee recently appointed by the Association "to Collect and Correlate Information Concerning the Corrosion of Iron and Steel Pipes and Standpipes." Members are urged to send data relating to the characteristics of the metal, the soil, the water and the protective coatings and to the history and condition of such supply mains (not service pipes) to the undersigned for the use of the Committee.

CALEB MILLS SAVILLE, *Chairman.*
1026 Main Street, Hartford, Conn.

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JOHN FOX & CO.

CAST IRON

WATER & GAS PIPES

FLANGE PIPE

Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

WOOLWORTH BUILDING 233 BROADWAY

NEW YORK CITY

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments

use

LEAD-LINED IRON and TIN-LINED PIPES

for their service connections

MANUFACTURED BY

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PIERCE-PERRY CO.
SUCCESSORS TO
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JOBBERS OF
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Hoffman Valves and Controlled Heat Equipment
236 Congress Street, Boston.

We Carry in BOSTON STOCK for Immediate Shipment
CAST IRON BELL AND SPIGOT WATER PIPE AND FITTINGS
FLANGED PIPE in full and short lengths
WROUGHT PIPE
FRED A. HOUDLETTE & SON
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CEMENT LINED SERVICE PIPE
With Specially Adapted
Lead-lined Fittings
Also Curb Cocks which eliminate Iron to Brass Corrosion both inside and out.
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Water Works Contractors and Supply Houses!
Your card may be inserted as above at a rate of $12 per year.

A Classified Directory
of Advertisements is arranged for your convenience in the back of this Journal.

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For Standard and High Pressure Service

Mathews Hydrants are simple in construction; hence durable, easily repaired, and maintained at low cost.

A real Frost Case makes Mathews Hydrants completely frost proof, and with an easily installed

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makes the Mathews readily adaptable to new grades and conditions.

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CAST IRON PIPE FITTINGS

"Sand-Spun" centrifugally cast pipe
Cast in refractory molds
No chill—Standard bell and beaded spigot

R. D. WOOD & CO.

PHILADELPHIA, PA.

KENNEDY

VALVES-PIPE FITTINGS-FIRE HYDRANTS

Open or closed—
always dependable

THE men who operate Kennedy Valves know they can always be depended upon to close tightly, release promptly, and respond to every service demand. For half a century and in thousands of plants, Kennedy Valves of every type and size have been demonstrating these characteristics and establishing the Kennedy reputation for thorough reliability.

Kennedy products include gate, globe, angle and check valves for every water works service.

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THE KENNEDY VALVE MFG. CO.
Elmira, N. Y.

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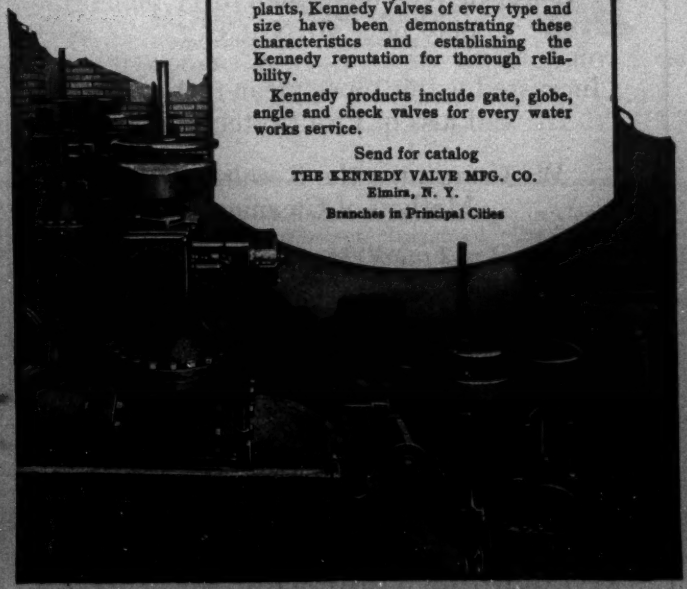

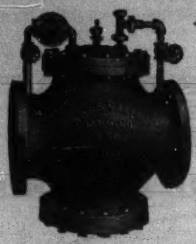

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ESTABLISHED 1879

Health and Protection First

Water delivered through dirty pipes may be a MENACE.

Incrusted water pipes mean inefficiency and loss of Fire Protection.

We Guarantee the Results of Our Method of Cleaning.

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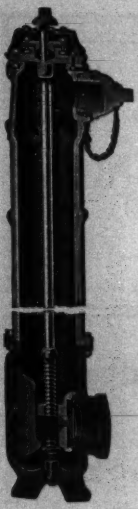

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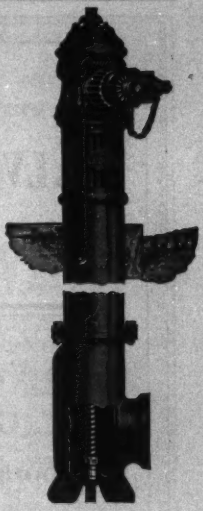
VALVES and FIRE HYDRANTS



This hydrant is anti-freezing, because when the drainage is good no water is left in it to freeze.

The drip is directly in the bottom of the hydrant and drains perfectly. It is protected by its valve, which never leaves its socket and cannot be clogged.

DOUBLE AND SINGLE GATE **VALVES,**

ALSO CHECK **VALVES,**

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FIRE **HYDRANTS.**

YARD, WASH, AND FLUSH **HYDRANTS.**

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The Knuckle Joint Principle in Genuine "Rensselaer" Improved "Corey" Fire Hydrants—Means Ease of Operation

BECAUSE this principle gives great power to open or close the gate just when it is needed, and speed in movement when power is unnecessary.

The first turn of the spindle, when the gate is open, moves the valve nearly two inches, after which the speed decreases and power throughout the knuckle joint increases, until at the time of closing the valve moves scarcely one-sixteenth of an inch at each turn of the spindle, eliminating danger from water hammer when closing hydrant.

The gate is closed very tight with slight application of power to the wrench by the operator. The drip valve in the Corey Fire Hydrant prevents freezing. No accident or damage to property can occur with this hydrant by flooding the streets where runaway teams or other accident breaks off or otherwise injures the hydrant standpipe, if hydrant was properly closed at time of accident.

It will be readily seen that the hydrant gate is held in position when shut by the four arms forming braces between the back of the hydrant and the seat, consequently the hydrant barrel can be broken completely off above the ground, but the valves remain tight.

Write for copy of our Hydrant Book No. 9.

CHARLES L. BROWN,

New England Sales Manager, Lock Box 2, Northboro, Mass.

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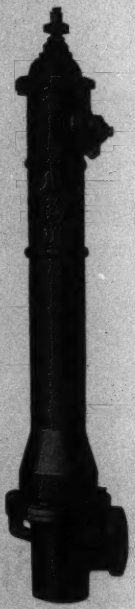

Type of Eddy Hydrant Popularly Used

More Than Sixty Years of Experience Goes Into All

EDDY

Hydrants and Valves

BUILT TO MEET EVERY EXACTING REQUIREMENT OF WATER-WORKS SERVICE

Practical water-works men instantly recognize the superior features of Eddy products. For instance, with the hydrant.

A damaged valve can be replaced in a few minutes — Water hammer is avoided by the valve closing against the pressure and the use of the cut-off under the valve, which gradually closes it —
Stems cannot be bent in closing the hydrant.
Nothing can lodge on the valve seat to prevent closing of the valve —
The Drip Rod can be removed without interfering with the hydrant in any manner —
The position of the stem of the hydrant indicates accurately the position of the valve —
Whatever can pass the valve opening will pass the standpipe —
No frost case necessary —
All of these points are explained thoroughly in our catalogue, which will pay you to study.

The Eddy Valve, Too

Has its distinctive and individual features. The double disk gates are free to adjust themselves in different positions every time the valve is closed, thereby keeping smooth and tight faces. And two bronze hooks on the ball loosely engage with the gates to prevent them from spreading at the top. The center bearing gates are forced to their seats with equal pressure at all points. There is a good deal more worth knowing about Eddy Valves. Further details will be sent for the asking.

Other Eddy Products

The Eddy line of water-works products also includes horizontal and vertical check valves, foot valves, hydraulically operated valves, indicator posts, etc.
All goods made by the Eddy Valve Company are manufactured exclusively at Waterford, New York.

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CAST IRON PIPE

...AND...

Special Castings for Water and Gas.
Also Flange Pipe, Street Castings,
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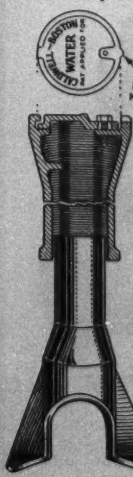
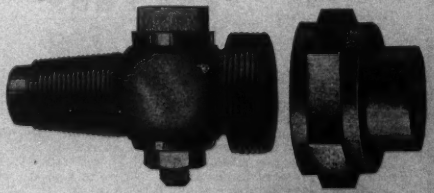
The "BEST" Cast Iron Curb Box

Top section is interchangeable with the "Slide Type" Buffalo Box



No change necessary in wrench or shut off keys



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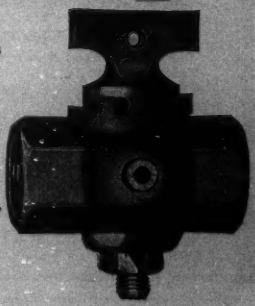
Brass Goods, Curb and
Valve Boxes

None better and few as good



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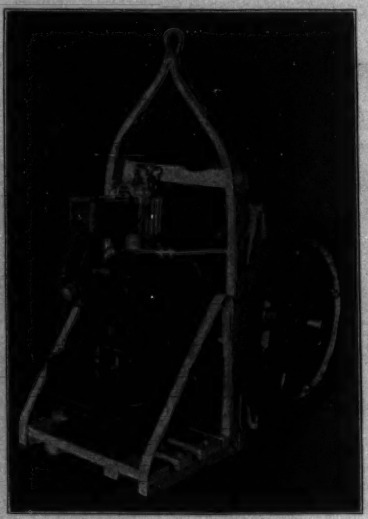

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TRAILER PUMP UNIT

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Light
Compact
Efficient

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Bell and Spigot Flanged Pipe
Special Castings
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LEADITE

Louisville, Ky. has used LEADITE for jointing 165.82 Miles of Water Mains

In fact, since 1923 the Louisville Water Co., Louisville, Kentucky has used LEADITE "exclusively" for jointing cast iron water mains varying in sizes up to and including 48", working pressures from 90 lb. per sq. inch down.

The reason why the Louisville Water Company has used LEADITE exclusively since 1923 is probably best explained in a recent letter from Mr. John Chambers, Chief Engineer and Superintendent, which reads in part as follows:

"These water mains have been in service six years and less and the joints are tight. Some of the lines were tested by the Pitometer Company of New York and no appreciable leakage was found."

"I consider LEADITE perfectly satisfactory as a joint material for cast iron bell and spigot pipe. The best that I can say for the material is that the Louisville Water Company intends to continue its use."

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 30 years.
Saves at least 75%

THE LEADITE COMPANY
Land Title Bldg. Philadelphia, Pa.

No Caulking

National-Boston Lead Co.

800 Albany St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

PIG LEAD

Joints that are Stress and Vibration Proof

Unusual situations often met in laying bell and spigot pipe — lines over bridges or railroad crossings — lines to be lowered to grade — are successfully met when the joints are made with Hydro-Tite.

Easy to Prepare

The 8-in. line pictured above is slung across a pond with cables — a span of more than fifty feet.

Every test shows that Hydro-Tite joints will remain perfectly tight when subjected to severe vibration or deflection. If you have never used Hydro-Tite let us tell you more about it. Requires no caulking — 19 years of proven dependability — a real 75% saving and an ever-increasing list of satisfied users.

Easy to Pour

Write for literature and further information.

HYDRAULIC DEVELOPMENT CO.

50 Church St., New York, N. Y.

BOSTON OFFICE & WORKS
296 Boylston St.

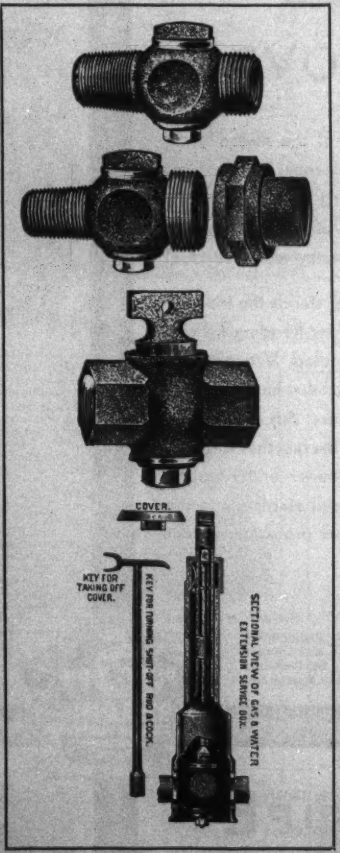
CHICAGO OFFICE
7 So. Dearborn St.

HYDRO-TITE

REG. U. S. PAT. OFF.

The Modern Joint Material

"The Goods That Please"



Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

Let us send at our risk, on 30 days' trial, a

Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

Established 1869

UNDER GROUND— OR ABOVE

When pipe resists all five of the major forces that tend to lower pipe endurance, it's bound to be good. That's what Reading 5-Point Pipe does —and that's why Reading 5-Point Pipe effects such remarkable economies in water works service!

Behind Reading 5-Point Pipe stands the indisputable record of the years—for Reading 5-Point Pipe is made of Genuine Puddled Wrought Iron, the same time-tested material that has proved its worth through long ages of use. An overwhelming mass of evidence attests the fact that Reading 5-Point Pipe lasts for generations—under ground or above! The Reading 5-Point emblem and the Reading indented spiral mark protect you from substitutes.

READING IRON COMPANY, Reading, Pa.

Atlanta · Baltimore · Cleveland · New York · Philadelphia
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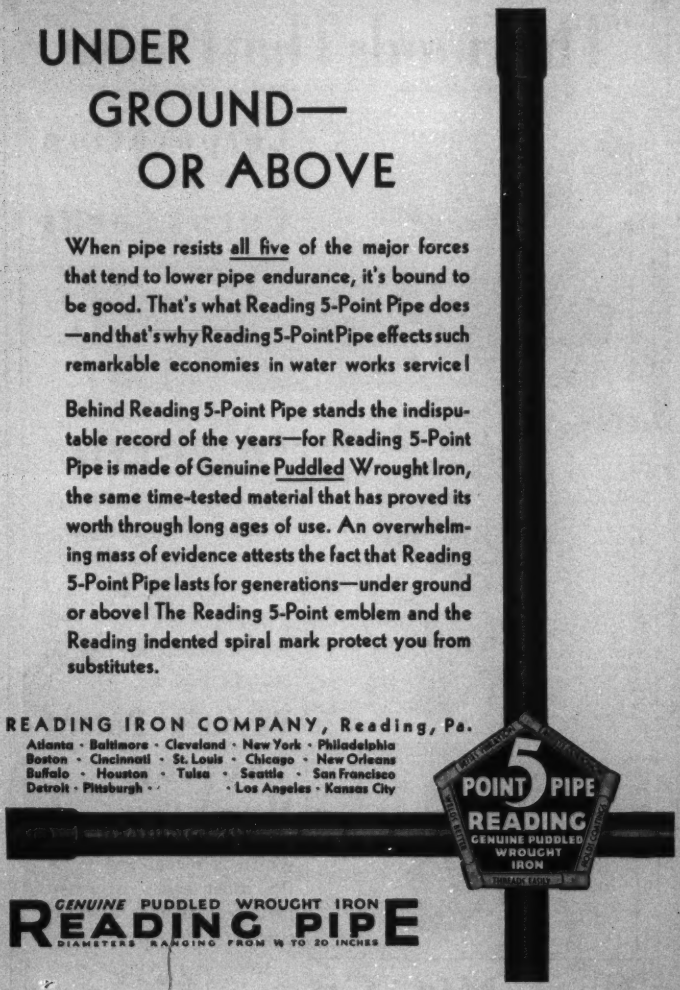
Detroit · Pittsburgh · · Los Angeles · Kansas City



GENUINE PUDDLED WROUGHT IRON
READING PIPE
DIAMETERS RANGING FROM ¼ TO 20 INCHES

GOLDEN-ANDERSON

Patent Automatic Cushioned Controlling Altitude Valves

We have enlightened many a water user in municipalities, in industrial plants and on railroads, as to the adaptability of these Golden-Anderson Valves, and as to their function of SAVING, and of eliminating troubles.

For automatically maintaining Uniform Stage of Water in Tank, Reservoir or Standpipes. Doing away with the annoyance of Freezing and Float Fixtures inside or outside of Tanks.

"Three Ways of Closing These Valves":
1st —Automatically, by water.
2nd—By Electricity, if desired.
3rd—By Hand

May also be arranged to automatically close when a break occurs in the mains. When necessary they may be so connected as to "work both ways" on a single line of pipe. No valves or fixtures inside or outside.

Sizes to 24 in.

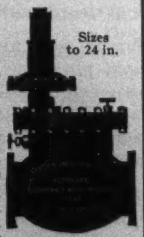
Remember!

"HOSTS OF REFERENCES"
Valves cushioned at all times by air and water
No water hammer or bursting mains

"Made with stop starter attachment for centrifugal pumps"

GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Pressure Regulating Valves

1. Maintain a constant reduced pressure regardless of fluctuations on high pressure side.
2. Perfectly Cushioned by water and air. No metal-to-metal seats.
3. The best valve made for maintaining a constant low pressure where consumption is continuous.
4. Operates quickly or slowly as required — No attention necessary.
5. Positively no hammering or sticking.



Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Cushioned Controlling Float Valves

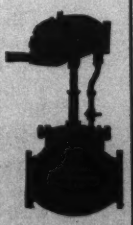
They carry a constant water level in feed water heaters by perfectly controlling the flow of makeup water.

Operated by protected enclosed copper float.

Cushioned by both air and water.

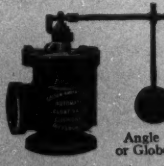
Operate without hammering, sticking or chattering. No metal-to-metal seats. Made angle or straightway.

Sizes 1 in. to 24 in.



GOLDEN-ANDERSON
Pat. Automatic Cushioned Water Float Valves

1. Automatically Maintain Uniform Water Levels in Tanks, Standpipes, etc.
2. Instantly Adjusted to Operate Quickly or Slowly.
3. Floats Swivel to any Angle — Most Satisfactory Float Valves Known.
4. No Metal-to-Metal Seats — No Water Hammer or Shock.
5. Cushioned by Water and Air.



Angle or Globe

Sizes to 24 in.

GOLDEN-ANDERSON
Patent Automatic Double Cushioned Check Valve

Sizes to 24 in. Angle or Globe

Automatically prevents reverse flow of pressure.

Perfectly cushioned to prevent shock or hammer.

Especially adapted for water works to prevent disastrous reverse flow of pressure due to pumps stopping.

Arranged so that quick or slow operating may be obtained.

Golden-Anderson Valve Specialty Co., 1325 Fulton Bldg., Pittsburgh, Pa.

Do this much for the health of your community.....

WHAT is more important to the health of your city than water?...You build huge storage systems to provide plenty for everyone. You take elaborate pains to guard its purity. Yet, in spite of this, in many houses water comes from the faucets contaminated...*with rust!*

Two ways to end this rust menace lie within your power. First, you can use *rust-proof* service pipe of Brass or Copper. Second, you can urge property owners to install Brass pipe or Copper tubing in their homes at the time of building. Used in both places, Brass or Copper assures a full, constant flow of clear, healthful water.

Brass pipe and Copper tubing are not only the most satisfactory forms of household plumbing, they are also the most economical. Although their first cost is slightly higher than that of corrodible pipe, their long life and immunity to deterioration make them decidedly economical in the long run.

This association will be glad to supply full information about Brass pipe and Copper tubing, or cooperate with you in any efforts you care to make toward furthering their use in the homes of your community.

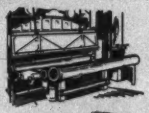
COPPER & BRASS
RESEARCH ASSOCIATION
25 Broadway, New York

Midwestern Office:	*Canadian Office:*	*Pacific Coast Office:*
Landreth Building	67 Yonge Street	Architects Building
St. Louis, Mo.	Toronto, Ont.	Los Angeles, Calif.

COPPER, BRASS, BRONZE—THE WORLD'S MOST USEFUL METALS

This water-cooled metal mold

and this annealing furnace



transform crude cast iron

into the fine grained

metal of deLavaud pipe which is strong and flexible

Examine a section of deLavaud cast iron pipe and note the fine and even grain of the metal. Laboratory tests have shown that because of this structure, deLavaud pipe combines flexibility with at least 25% greater strength.

The reason for the fine granular structure of deLavaud pipe metal is due to its unique process of manufacture. de Lavaud pipe is cast in a rapidly revolving cylindrical mold. This mold is cooled by a specially constructed water jacket. When the molten iron comes in contact with the chilled surface of the mold, the abrupt change of temperature brings about the uniformly fine division of the iron particles.

Immediately upon leaving the machines, every length of de Lavaud pipe is placed in a large annealing oven. Here *accurately controlled* heat further improves the metal, eliminating all possibility of casting strains, and bringing about the flexibility and strength that only deLavaud pipe can offer.

Let us send you the deLavaud handbook which contains complete information about deLavaud pipe and fittings.

Our pipe bears the "Q-shield" endorsement of The Cast Iron Pipe Research Association.

United States Pipe and Foundry Co., Burlington, New Jersey

Sales Offices: New York, Philadelphia, Pittsburgh, Cleveland, Buffalo, Chicago, Dallas, Birmingham, Kansas City, Minneapolis, Seattle, San Francisco, Los Angeles

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There are over 500 PARADON ..dry feed.. CHLORINATORS IN SERVICE

Over 5 years ago the first Paradon Dry Feed Chlorinator was installed. It is still functioning perfectly, and so are over 500 other PARADON Dry Feed Chlorinators — and they are operating on practically every type water supply, sewage plant and swimming pool.

The Dry Feed Chlorinator is simpler, easier to install and more economical to operate. The number of parts are approximately one-third that of any other type. Water, power, freezing, drains, piping, injector, and as many other items are eliminated.

Bulletin No. 21 recently issued describes the Paradon line of Dry Feed Chlorinators in detail. It's yours for the asking.

PARADON MFG. CO.
Arlington, N. J.

Paradon CHLORINATORS
for
City and Private Water and Sewage Systems, Industrial Plants and Swimming Pools.

N-17am.

Bulletin No. 20 recently issued describes the Paradon Chlorinator for small water supplies.